THE RELATIONSHIP BETWEEN ANTHROPOMETRY, DIETARY INTAKE AND TYPE 2 DIABETES MELLITUS IN WOMEN (25 - 44 YEARS) IN MANGAUNG

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Declaration of independent work:

DECLARATION WITH REGARD TO INDEPENDENT WORK

I, ZORADA HATTINGH, identity number [redacted] and student number [redacted], do hereby declare that this research project submitted to the Technikon Free State for the Degree MAGISTER TECHNOLOGIAE: FOOD AND NUTRITION, is my own independent work; and complies with the Code of Academic Integrity, as well as other relevant policies, procedures, rules and regulations of the Technikon Free State; and has not been submitted before to any institution by myself or any other person in fulfilment of the requirements for the attainment of any qualification.

SIGNATURE OF STUDENT _____ DATE _____

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SUMMARY

South Africa, like many other countries, is a country in transition, leading to political, demographic, social, economical, and nutritional changes, affecting particularly the African population. This new era is characterised by changes from the traditional lifestyle, to a more western lifestyle and eating habits, associated with chronic diseases of lifestyle, including type 2 diabetes mellitus.

Type 2 diabetes mellitus, which affects an increasing number of people in South Africa, including the African population, is characterised by insulin resistance, a dysfunction of the insulin secreting beta cells of the pancreas, and reduced receptor binding characteristics, leading to high blood glucose levels, and metabolic abberations.

Risk factors for this disease include aging, gender, genetic factors, change in lifestyle factors, socio-economic factors, obesity, and some metabolic disorders. The serious health complications associated with type 2 diabetes, emphasise the need to address this disease urgently.

The effect of the nutrition transition, including the increase in chronic diseases of lifestyle, has prompted the need to determine the association between anthropometry, dietary intake and type 2 diabetes mellitus.

A representative sample of 500 African women, (age groups 25-34, and 35-44 years), from the Mangaung area of Bloemfontein, was selected for the study.

The socio-demographic composition of the subjects was determined by means of a questionnaire. Weight, height, circumference (waist and hip), and bio-impedance measurements were obtained,

and used to calculate body mass index, fat distribution and fat percentage of respondents. Dietary intake was determined by means of a standardised food frequency questionnaire, and analysed to determine the habitual food intake of respondents. Blood samples were collected to determine the triglyceride, total cholesterol, serum albumin, serum glucose, and serum insulin status of each subject.

Anthropometric results included body mass index, fat distribution and fat percentage. More than fifty percent of respondents had a body mass index above 25. Fat distribution showed a gynoid fat distribution, with 83.5 percent of the women from the younger group, and 62.7 percent of women from the older group having a waist-hip-ratio smaller than 0.8. The fat percentages of women from both age groups were high. From the younger women, 92.5 percent, and from the older women 94 percent showed fat percentages that exceeded the normal fat percentage.

Median dietary intakes indicated high intakes for energy, macro-nutrients and cholesterol. Median intakes of the macro-nutrients and cholesterol calculated as percentage of the total daily energy intake showed that median percentage of protein, saturated fats, mono-unsaturated fats, and poly-unsaturated fats fell within recommendations, while median percentage of total fat intake exceeded recommendations. Median intakes of chromium, potassium, manganese, and phosphorus were high. Low median intakes were reported for calcium, total iron, copper and selenium, vitamins A, C, D, E and folate.

The thirty most frequently consumed foods by mass, indicated that although traditional foods are still popular, more Western foods and beverages are also being chosen.

Biochemical parameters indicated that most women from the two age groups had normal fasting triglycerides, serum albumin, serum glucose and serum insulin levels, while fasting cholesterol levels seemed to increase with an increase in age.

Although the prevalence of type 2 diabetes in this population was low, a significant risk for the development of diabetes was identified, as indicated by the significant association between insulin sensitivity and body mass index, and the association between insulin resistance and triglycerides.

Reverting to a more traditional lifestyle, including diet and physical activity, could assist in alleviating the conditions of over-and under nutrition, and unfavourable anthropometric and biochemical parameters associated with the health status of these African women.

OPSOMMING

Suid-Afrika, soos baie ander lande, beleef tans 'n oorgangsperiode, wat tot politieke-, demografiese-, sosiale-, ekonomiese- en voedingsveranderinge lei. Hierdie veranderinge raak veral die swart bevolking. Dié nuwe era word gekenmerk deur veranderinge in die tradisionele leefstyl, na 'n meer westerse leefstyl en eetgewoontes, wat met sommige chroniese siektes, insluitende tipe 2 diabetes verband hou.

Tipe 2 diabetes, 'n Derde-Wêreld probleem, wat 'n toenemende getal inwoners in Suid-Afrika, insluitende die swart bevolking affekteer, word gekenmerk deur insulien weerstandigheid, wanfunksionering van die insulien-produserende beta-selle van die pankreas, en verlaagde reseptor-bindingseienskappe, en lei tot verhoogde bloedglukose vlakke, en metaboliese afwykings.

Risikofaktore vir hierdie siektetoestand sluit veroudering, geslag, genetiese faktore, veranderinge in leefstyl, sosio-ekonomiese faktore, vetsug, en sommige metaboliese afwykings in. Die ernstige gesondheidskomplikasies wat met tipe 2 diabetes geassosieer word, noodsaak die behoefte om hierdie toestand onmiddellik aan te spreek.

Die invloed van die voedingsoorgangsperiode, insluitende die toename in chroniese leefstylsiektes, het die behoefte om die verband tussen antropometrie, dieet-inname, en tipe 2 diabetes mellitus te bepaal, genoodsaak.

'n Verteenwoordigende steekproef van 500 swart vrouens (ouderdomsgroepe 25-34, en 35-44 jaar), van die Mangaung-gebied van Bloemfontein, is vir die studie gekies.

Die sosio-demografiese samestelling van die respondente is deur middel van 'n vraelys bepaal. Gewig, lengte, omtrekke (middel en heup), en bio-impedansmates is verkry, en gebruik om liggaamsmassa-indeks, vetpersentasie, en vetverspreiding van respondente te bepaal. Dieetinname is deur middel van 'n gestandaardiseerde voedsel-frekwensie vraelys bepaal, en ontleed om die gewoontelike voedselinname van respondente te bepaal. Bloedmonsters is versamel om die trigliseried-, totale cholesterol-, serum albumien-, serum glukose-, en serum insulien waardes van elke respondent te bepaal.

Antropometriese resultate het liggaamsmassa-indeks, vetpersentasie en vetverspreiding ingesluit. Meer as vyftig persent van die respondente het 'n liggaamsmass-indeks bo 25 getoon. Vetverspreiding het 'n ginoïde verspreiding aangetoon, met 83.5 persent van die jonger vrouens, en 62.7 persent van die ouer vrouens wat 'n middel-heup-omtrek verhouding van kleiner as 0.8 gehad het. Die vetpersentasie van vrouens van beide ouderdomsgroepe was baie hoog. Van die jonger vrouens het 92.5 persent, en van die ouer vrouens 94 persent 'n vetpersentasie hoër as die normale getoon.

Mediaan dieetinnames het hoë innames vir energie, makro-voedingstowwe, en cholesterol aangetoon. Mediaan innames van die makro-voedingstowwe en cholesterol bereken as persentasie van die totale daaglikse energie-inname het mediaan persentasie-innames van proteïen, versadigde vette, mono-onversadigde vette, en poli-onversadigde vette getoon wat binne die aanbevelings val, terwyl die mediaan persentasie inname van totale vette aanbevelings oorskrei het. Mediaan innames vir chroom, kalium, mangaan, en fosfor was hoog. Lae mediaan innames is vir kalsium, totale yster, koper, en selenium, vitamien A, C, D, E en foliensuur gerapporteer.

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Die dertig mees gereelde voedsel volgens massa verbruik, het aangetoon dat alhoewel tradisionele voedsels steeds gewild is, Westerse voedsels en dranke ook verkies word.

Biochemiese parameters het aangetoon dat meeste vrouens van beide ouderdomsgroepe normale vastende trigliseried-, serum albumien-, serum glukose-, en serum insulienvlakke het, terwyl dit blyk asof vastende cholesterolvlakke toeneem met 'n toename in ouderdom.

Alhoewel die voorkoms van tipe 2 diabetes mellitus in die populasie laag was, is 'n risiko vir die ontwikkeling van diabetes geïdentifiseer, soos blyk uit die beduidende verband tussen insuliensensitiweit en liggaamsmassa-indeks, en 'n verband tussen insulien weerstandigheid en trigliseriedvlakke.

Die terugkeer na 'n meer tradisionele leefstyl, insluitende dieet en fisiese aktiwiteit, kan 'n bydra lewer in die verligting van toestande van oor- en ondervoeding, asook ongunstige antropometriese- en biochemiese parameters, wat met die gesondheidstatus van hierdie swart vrouens geassosieer word.

TABLE OF CONTENTS PAGES

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AI	adequate intake
β-cell	beta-cell
BCG	bromcresol green
BIA	bioelectrical impedance
BMI	body mass index
BRISK	Coronary Heart Disease Risk Factor Study in the African Population of the Cape Peninsula
CARDIA	Coronary Artery Risk Development in Young Adults
CAD	coronary artery disease
CI	confidence interval
cm	centimeter
CORIS	Coronary Risk Factors Resurvey
CRISIC	Coronary Risk Factor Study among the Coloured Population of the Cape Peninsula
CV	coefficient of variation
°F	degrees Fahrenheit
FFA	free fatty acids
FFQ	food frequency questionnaire
g	gram
g/day	grams per day
g/l	grams per liter

GOD	glucose-oxidase
IDDM	insulin-dependent diabetes mellitus
kg	kilogram
kJ	kilojoules
mg	milligram
mg/day	milligrams per day
ml	milliliter
mm	millimeter
mmol/l	millimol per liter
MUFA	mono-unsaturated fatty acids
NCHS	National Centre for Health Statistics
NEFA	non-esterified fatty acids
NIDDM	non-insulin-dependent diabetes mellitus
POD	peroxidase
PUFA	poly-unsaturated fatty acids
Q	quartile
RA	rates of appearance
RDA	recommended dietary allowance
Re	retinol
SAT	sub- cutaneous adipose tissue
SD	standard deviation
TAT	total adipose tissue
TE	total energy
TG	triglycerides
THUSA	Transition and Health during Urbanisation of South Africans
Trp64Arg	substitution of tryptophan for arginine at codon 64

µg	micro gram
µU/ml	micro units per milliliter
VAT	visceral adipose tissue
W/H^2	W is weight in kilograms and H is height in square meters
WHR	waist-to-hip circumference ratio
WR	weighed record
$\frac{\bar{x}}{sd} \times \frac{100}{1}$	standard deviation divided by average
>	bigger than
<	smaller than
≥	equal to, and bigger than
≤	equal to, and smaller than

LIST OF APPENDICES

LIST OF APPENDICES

CHAPTER 1

THE NUTRITION AND HEALTH TRANSITION

1.1 INTRODUCTION

Globally, the general health and nutrition situation has changed tremendously from the early periods to the end of the 20th century (Walker & Segal, 1997). From a nutrition perspective, research and policies in many lower-income countries, have previously focused on problems of undernutrition (Popkin, 1994; Popkin & Doak, 1998). A marked decline in infectious diseases, and a movement towards an increase in chronic diseases have now become the epidemic faced worldwide (Musaiger, 1992; Monteiro et al., 1995; Kim et al., 2000). These degenerative chronic diseases such as diabetes mellitus and obesity have become major health concerns around the world, especially among populations which have been subjected to a rapid change in lifestyle (O' Dea, 1991). Many developing countries, such as South Africa, are however experiencing a health transition in which the double burden of chronic diseases and infectious diseases will have to be fought simultaneously (Bourne et al., 1993; WHO, 1998).

Women's health in South Africa, and particularly women living in peri-urban areas, is being influenced by three major factors. These include the political transition from apartheid to democracy, rapid urbanization and the internationally growing awareness of the need for health care. The development of appropriate health services for women has now become a priority. Westernization and urbanization are internationally receiving more recognition as major determinants of health. The global process of urbanization in South Africa has been predicted to increase to 75 percent of the population by the year 2000 (Hoffman et al., 1997), affecting mainly the African population (Bourne et al., 1993). This condition leads to considerable urban poverty and the growth of informal settlements, which have a profound effect on the population's health status, as these previous rural dwellers now adopt new ways of life (Hoffman et al., 1997).

The demographic transition is described as the shift from a pattern of high fertility and high mortality, to low fertility and low mortality, typical of modern and industrialized nations (Popkin, 1994).

Even more directly related, is the epidemiologic transition, which has been described as the shift from a pattern in which pestilence, famine, and poor sanitation lead to a high prevalence of infectious diseases and malnutrition, to a pattern in which the prevalence of chronic and degenerative diseases is high (Bourne et al., 1993; Popkin, 1994; Romieu et al., 1997; WHO, 1998). This epidemiologic transition, particularly the rapid shift in morbidity and mortality patterns toward much higher rates of noncommunicable diseases (NCD), is now dominating the health profile of an increasingly larger number of persons in middle- and lower-income countries (Bourne et al., 1993; Monteiro et al., 1995; Popkin, 1998). In 1985, the World Health Organisation estimated that non-communicable diseases will account for 15 - twenty percent of all deaths in developing countries by the year 2000 (WHO, 1985). Current figures however, indicate that coronary heart disease, stroke and other NCD now cause an alarming 39 percent of all deaths in developing countries, with these diseases also affecting younger people in developing countries more often than in developed countries (WHO, 1998).

An increasing number of the estimated 12 million global deaths per year caused by coronary heart disease and stroke, occur in developing countries (WHO, 1998). Data obtained from deaths reported to the Central Statistical Services in 1988, indicated that chronic diseases of lifestyle were responsible for 24,5 percent of all deaths in South Africa. These data highlight the urgent need to address these diseases in South Africa (Steyn et al., 1992).

Wealth and poverty have extreme effects on diet, nutrition and health (Popkin, 1994), with the rich becoming richer, and the poor becoming poorer. This inequality in income is reflected in inequalities in health (Walker & Segal, 1997). The major dilemma facing the health and nutrition profession in any country is therefore how to best promote economic growth, reduce infectious diseases, and delay or prevent the onset of NCD (Drewnowski & Popkin, 1997).

1.2 THE NUTRITION TRANSITION

The concept of the nutrition transition is described as "a sequence of characteristic dietary and nutritional patterns resulting from large shifts in overall dietary structure, related to changing economic, social, demographic and health factors" (Popkin, 1993). Most countries which have undergone a rapid nutrition transition during this century, share some common features. Generally, there seems to be a progression from a period in which countries attain dietary sufficiency, i.e. adequate energy and protein intake, to one in which the shift in the structure of diet is the main source of nutritional change (Monteiro et al., 1995). The major shifts in diet structure occuring on a worldwide basis in lower-income countries, are characterized by a large increase in the consumption of more diverse diets including higher proportions of refined grains, fat, vegetable oils, sugar, meat and eggs, often termed the "Western diet" (Popkin, 1994; Monteiro et al., 1995), in comparison with the traditional diet high in coarser grains (Monteiro et al., 1995; Popkin & Doake, 1998). The typical African diet consists of 23 percent fat, 53 percent complex carbohydrates and 23 percent proteins, of which seventy percent is obtained from plant sources (Gresse et al., 1993).

From the point of food intake, the historical sequence of the nutrition transition can be described in five broad patterns, as summarized by Popkin (1994) in Figure 1.1.

Social and economic factors	PATTERN 1: Collecting food	PATTERN 2: Famine	PATTERN 3: Receding Famine	PATTERN 4: Degenerative Diseases	PATTERN 5: Behavioural Change
Nutrition					
Diet	Plants, wild animals; varied diet	Cereals predominant; diet less varied	Fewer starchy staples; more fruits, vegetables, animal protein; low variety continues	More fat (especially from animal products), sugar, and processed foods; less fibre	Less fat and processing; increased carbo-hydrates, fruits, and vegetables
Nutritional status	Robust, lean, few nutritional deficiencies	Children, women suffer most from low fat intake; nutritional deficiency diseases emerge; stature declines	Continued maternal/child nutrition problems; many deficiencies disappear; weaning diseases emerge; stature grows	Obesity; problems for elderly; many disabling conditions	Reduced body fat levels and obesity; improved bone health
Economy	Hunter-gatherers	Agriculture, animal husbandry, home-making begin; shift to monocultures	Second agricultural revolution (crop rotation, fertilizer); Industrial Revolution; women join labor force	Fewer jobs with heavy physical activity; service sector and mechanization; household technology revolution	Service sector mechanization, industrial robotization dominate; leisure exercise grows to offset sedentary jobs
Household production	Primitive; onset of fire	Labor-intensive primitive technology begins (clay cooking vessels)	Primitive water systems; clay stoves; cooking technology advances	Household technology mechanized and becomes more varied	Food preparation technology changes rapidly
Income and assets	Subsistence; primitive stone tools	Subsistence, few tools	Increasing income disparity, agricultural tools, industrialization rises	Growth in income and income disparities	Income growth slows; home and leisure technologies increase
Demography					
Mortality/fertility	Low fertility, high mortality; low life expectancy	High natural fertility, low life expectancy, high infant and maternal mortality	Mortality decline; fertility static, then declines; cumulative population growth	Life expectancy reaches high levels (60s-70s); fertility low and fluctuating	Life expectancy extends to 70s, 80s; disability-free life expectancy increases
Morbidity	Much infectious disease; no epidemics	Epidemics; endemic disease (plague, small-pox, polio, TB); deficiency disease begins; starving common	TB, smallpox, infection, parasitic disease, polio, weaning disease (diarrhea, retarded growth) expand, later decline	Chronic disease related to diet pollution (heart disease, cancer); infectious disease declines	Increased health promotion (preventive and therapeutic); decline in coronary heart disease, improvement in age-specific cancer profile
Age structure	Young population	Young; very few elderly	Chiefly young; shift to older population begins	Fertility decline; elderly proportion increases	Increasing proportion of elderly > 75 years

Figure 1.1: Broad changes in Dietary Patterns and their relationship to social and economic factors (Adapted from Popkin, 1994).

Recent studies have revealed that when Australian Aborogines, Pima Indians and other native American Indians, as well as numerous Pacific Island populations made the transition from a traditional to a westernized lifestyle, they were particularly vulnerable to developing chronic degenerative diseases (O' Dea, 1991). For this group of people, the feasts in their traditional diet were usually provided by larger animals such as kangaroo, with low carcass fat in contrast to domesticated meat animals, or seafood such as fish and turtles. Small animals, fish, shellfish and vegetable foods collected primarily by the women, provided the daily subsistence diet (O'Dea, 1991). The transition of these traditional hunter-gatherers to a westernized lifestyle, usually leads to decreased energy expenditure and an increased consumption of energy-dense diets, high in saturated fat and fibre-depleted carbohydrates (O'Dea, 1991), resulting in increases in average body mass index (BMI), and the percentage of obese individuals (Seidell, 1998).

The nutrition transition in many lower-income countries such as South Korea, has been rapid (Kim et al., 2000). Information from Asian countries, nations in the Carribean region and South Korea, which were all lower income at the time of their transition, shows an accelerated change in diet structure after these countries attained dietary sufficiency at the national level (Kim et al., 2000; Popkin, 1994). In South Korea, a unique nutrition transition has however occurred. This country experienced earlier economic change than did most Asian countries. Concurrent changes in lifestyle included the rapid introduction of elements which may be termed a "Western lifestyle". The introduction of fast-food restaurants led to a new interest especially amongst the younger generation. Large shifts in the structure of the diet and disease pattern, reflected in increased body size and an increase in deaths from chronic diseases, became apparent. The uniqueness of the nutrition in this country however, lies in the fact that the dietary shift was not linked with an increase in fat intake as the country's income increased (Kim et al., 2000). There are several possible explanations for this low fat intake in South Korea, such as the high intake from carbohydrates in the form of rice, which is still the primary element of the South Korean diet (Moon, 1993). Other explanations may be the South Korean style of cooking, in which relatively small amounts of sesame oil are added to boiled or steamed food, as well

as strong movements in the form of mass media campaigns, and training programmes on cooking methods by extension workers, to retain the traditional Korean diet. Many countries can therefore gain important insight into the handling of problems associated with nutritional transition from the unique situation in South Korea (Kim et al., 2000).

The relationship between the demographic, socio-economic and epidemiologic changes that are responsible for the nutrition transition are complex. Younger age cohorts generally change more rapidly; hence with population ageing, an ever-increasing rate of change in the level of obesity and the shift toward the Western diet is visible. These dietary shifts, together with a more sedentary lifestyle first occur in urban areas, then spread to higher income segments of rural areas (Monteiro, et al., 1995). Trends associated with this dietary change and reduced physical activity, such as changes in body composition, in particular increases in obesity, are noteworthy in many countries (Monteiro et al., 1995; Popkin, 1994; Popkin & Doak, 1998; Popkin, 1998).

The association between incomes and diet structure at national and individual levels have been addressed by Drewnowski and Popkin (1997). These researchers noted that the global availability of cheap vegetable oils and fats have resulted in greatly increased fat consumption among low-income nations, with the nutrition transition consequently now occuring at lower levels of the gross national product than previously. This is further accelerated by high urbanization rates (Drewnowski & Popkin, 1997). In Brazil, where a rapid shift from the problem of dietary deficit to the problem of dietary excess has occured, profound changes between income status and the risk of female obesity have been reported. A larger proportion of obesity now occurs under low- and middle-income women (Monteiro et al., 1995).

It is however important to realize that the nutrition transition is characterized by a stepwise progression that depends on the balance of contributing factors. For example, whereas urbanization in more industrialized countries has been associated with economic growth, in many developing countries it results in urban poverty (Yach et al., 1990). In Cape Town, South Africa, urbanization has

resulted in the rapid developments of new townships, offering accomodations ranging from formal housing to squatting in both organized serviced sites and informal areas without services (Levitt et al., 1993).

Diets become more diverse as income grows, with more people including meat and fish, milk, eggs and cheese, sweets, as well as vegetables and fresh fruit, into their habitual diet. Some of these new foods are high in fats and simple sugars, or both (Drewnowski & Popkin, 1997). Factors such as the selection of food taking less time and skill to prepare and consume, may play a role in abandoning of traditional staple foods in favour of diets containing a higher proportion of sugars and vegetable or animal fats (Gopalan, 1992). Greater eating pleasure associated with a more varied diet than a limited diet consisting basically of little more than starchy roots and coarse grains, may also contribute to these dietary changes. Preferences for dietary sugars and fats are also regarded by many as an innate human trait (Drewnowski & Popkin, 1997).

Although many researchers in the West have claimed that a culture associated with increased availability of fast foods in markets and restaurants has been the driving force behind the global increase in fat consumption, data for lower-income countries do not support this claim (Drewnowski & Popkin, 1997).

The growth in urban populations, the unemployment status of many potential street food vendors, lengthening commutes for workers, and public demand for cheap food near workplaces, have lead to a rise in street food vendors (Oguntona & Kanye, 1995), playing a large role in the feeding of the urban poor. In Guatamala, the traditional diet of maize and beans has been replaced by a new pattern of dietary selection, and format of eating meals, in relationship to the size, congestion, economic evolution, and modernization of the city (Solomons, 1997).

In South Africa amongst others, people who grew up under adverse and disadvantaged circumstances have now adopted typical Western lifestyles and eating patterns (Vorster et al., 1999).

The urban African population In South Africa, presently experiencing rapid urbanization, currently consume about thirty percent of their energy as fat (MacIntyre, 1998; Bourne et al., 1993), while the diet of their rural counterparts is still very low in fat (Vorster et al., 1997). The contribution of total protein to energy intake does not vary much between these groups. The ratio of plant to animal protein intake however shows dramatic changes, with rural African women consuming more plant proteins. Higher intakes of fruit and vegetables, and consequently higher dietary fibre and micronutrient intakes, were observed among urbanized Africans, compared to their rural counterparts (MacIntyre, 1998).

1.3 DISEASES OF LIFESTYLE

Risky behaviour such as smoking, a typical unhealthy Western diet, and a sedentary lifestyle, results in the emergence of a range of risk factors, including tobacco addiction, hypertension, type 2 diabetes, hyperlipidemia and obesity. These risk factors eventually lead to chronic diseases of lifestyle such as ischaemic heart disease and cerebrovascular diseases, smoking related diseases and other related conditions.

"Obesity, Type 2 diabetes, hypertension and atherosclerotic cardiovascular disease are common metabolic disorders that are associated with insulin resistance and hyperinsulinaemia". This statement by DeFronzo and Ferrannini (1991) suggests that the dangers of hyperinsulinaemia could be as great or even greater than those related to hyperglycemia. It is not surprising that any subject over the age of 60 years might have one or more of these commonly existing diseases, since the body's sensitivity to insulin declines with age. A decline in glucose tolerance that is associated with a reduced responsiveness to insulin is marked in subjects older than 45 years of age. It is possible that the impaired glucose tolerance in elderly subjects may be primarily due to a decrease in insulin action upon glucose uptake. Since increasing age is also associated with obesity it could contribute to the insulin resistance in subjects over the age of 45 years (Ratzmann et al., 1982). Insulin resistance is also present in up to 25 percent of the normal population (Hollenbeck & Coulston, 1991).

The complex interactions between an unhealthy lifestyle, the resulting risk factors, and the ultimate range of chronic diseases of lifestyle with their major impact on mortality, are represented in Figure 1.2 (Steyn et al., 1992). The symbols indicate the interrelationship between an unhealthy diet and the various chronic diseases of lifestyle.

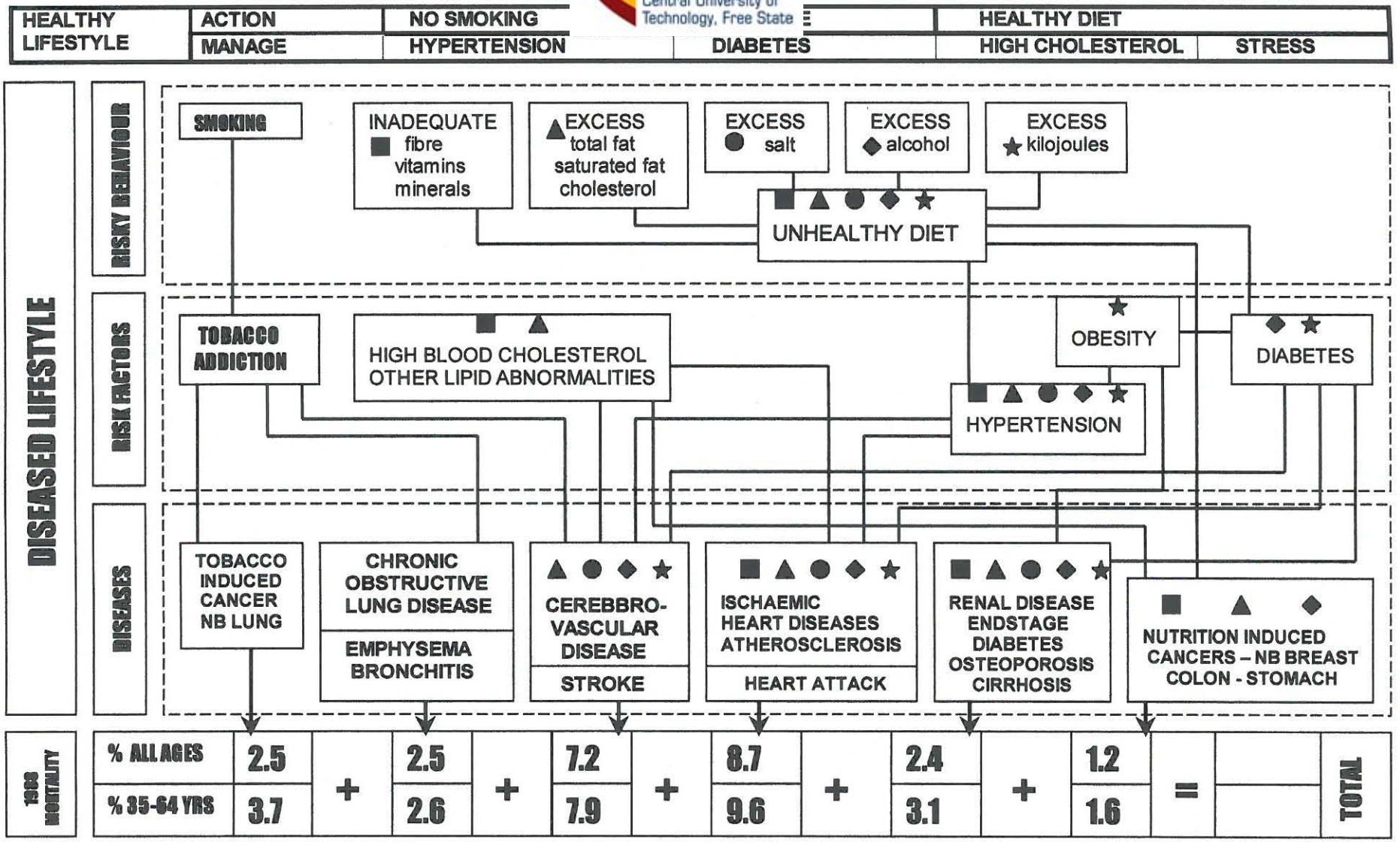

Figure 1.2 Chronic diseases of lifestyle (Adapted from Steyn et al., 1992)

1.3.1 OBESITY

Obesity, defined as a disease in which excessive body fat has accumulated to the extent that health may be adversely affected, is a complex and incompletely understood chronic disease (Kalk, 2001).

The role of adiposity in the development of chronic diseases, has received considerable attention in recent years. Obesity, defined as a BMI higher than thirty (National Institutes of Health, 1998), appears to have been very uncommon in centuries past. The majority of people were very poor, and in the main very physically active and muscular Trowell, 1975, as cited by Walker, 1995b. The technological revolution of the late 20th century has however brought about extreme changes in diet and activity patterns, overpowering our stable body weight regulatory mechanisms (Prentice, 1997). Obesity has now emerged as a serious health concern in industrialized nations (National Institutes of Health, 1998), with multifactorial causes, including polygenic, metabolic, psychosocial and environmental influences (Weinsier et al., 1998).

The common belief that obesity results simply from overeating or reduced physical activity is therefore an oversimplification, since diet restriction and physical exercise are rarely successful in the treatment of clinical obesity (Turner & Clapham, 1998).

A complex system of neural, hormonal and chemical mechanisms that keep the balance between energy intake and energy expenditure within fairly precise limits, aids in maintaining a constant body weight in most adults. Abnormalities of these mechanisms result in weight fluctuations, of which the most common are overweight and obesity (Laquatra, 2000, p. 486).

In 1998, the World Health Organization (WHO, 1998), published a report titled: "Obesity: preventing and managing the global epidemic", thereby recognizing that overweight and obesity

have become serious health implications in developing and developed countries (Ravussin, 2000a).

This chronic disease of lifestyle has also been described by Prentice (1999) as the "Obesity "Epidemic" and by James (1992) as a "pandemic". The following quote from Popkin & Doak (1998) further confirms the excessiveness of obesity: "We now face the emergence of obesity as a worldwide phenomenon, affecting wealthy and middle-income people alike in middle-income countries, as well as residents of countries previously considered to be poor" (Popkin & Doak, 1998). In affluent countries, obesity is primarily a disease of poverty, while in developing countries it started in the rich, and may still carry a positive stigma reflecting wealth and good living. It is however now becoming the disease of the urban poor (Prentice, 2000a).

The increased levels of obesity in countries such as South Africa, Mexico and Malaysia, are indicative of major health problems, indicating the need to understand the underlying environmental causes of this epidemic (Popkin & Doak, 1998). Ravussin (2000a) recently made the following statement regarding obesity: "Because of the many health risks associated with obesity, this disorder should be accorded the seriousness it deserves, and not be dismissed as the result of gluttony and/or lack of willpower".

Currently, the prevalence of obesity worldwide is estimated at 250 million people (Seidell, 1999). In established market economies such as Europe, USA, Canada and Australia, a weighed estimate suggests an average prevalence of obesity of 15 - twenty percent, with this prevalence showing increasing trends over time (Seidell, 1999). It has been estimated that the average Australian adult has been adding one gram a day to body weight (Magnus & Bennett, 1994), therefore gaining weight gradually (Prentice, 2000b). In Sub-Saharan Africa and Asia, where the majority of the world population lives, obesity is much less common than in Latin America. Obesity rates and rates of type 2 diabetes are however also on the increase in these countries

(Seidell, 1999).

In South Africa, factors that determine obesity, were found to be residence in urban areas, especially in the wealthiest provinces, namely Gauteng and the Western Cape, no education, or higher educational levels, and being of the female gender (Kalk, 2001).

1.3.1.1 HEALTH RISKS ASSOCIATED WITH OBESITY

Obesity in adults favours the development of a number of health problems and comorbidities or chronic diseases. The risk for hypertension, coronary artery disease, type 2 diabetes, certain cancers, and gallbladder disease increases with an increase in body weight Pi-Sunyer 1993, as cited by Walker, 1995 (Laquatra, 2000, p. 486). Obesity is also associated with an increased risk for degenerative joint disease, lipid disorders, obstructive sleep apnea and other respiratory conditions. It also doubles the risk of disability and immobility in women, and is a risk factor for poor wound healing and poor antibody response to hepatitis B vaccine (Laquatra, 2000, p. 486). Obesity is also linked to chronic hypoxia and hypercapnia, with centralized body fat enhancing the risk for most of these health conditions (Pi-Sunyer, 1993). Furthermore, obesity has certain social disadvantages, such as discrimination as far as admission to colleges, employment, promotion, access to housing, attribution of personality traits (Walker, 1995a), and self esteem are concerned (Walker, 1995b).

1.3.1.2 FAT DISTRIBUTION: ANDROID VERSUS GYNOID DISTRIBUTION PATTERNS

Vague already pointed out in 1953 that the association between centralized obesity and diabetes, gout, and atherosclerosis is stronger than with a more peripheral distribution pattern. Central obesity (also called upper-body fat, android obesity, or "apple-shaped figures") is made up of intra-abdominal or visceral adipose tissue (VAT) and truncal (abdominal) sub-cutaneous

adipose tissue (SAT) (Pi-Sunyer & Albu, 1999). This pattern of fat distribution may play an important role in the development of chronic diseases such as diabetes mellitus (Bjorntorp, 1984, Conway et al., 1995; Evans et al., 1984b), and macrovascular disease (Ahrens, 1984), also causing greater morbidity and mortality, particularly as a result of hypertension, hyperlipidemia, reduced glucose tolerance, hyperinsulinemia and insulin resistance (Evans et al., 1984b; Kissebah et al.; 1985; Pi-Sunyer & Albu, 1999). These risk factors associated with central obesity have collectively been termed the "metabolic syndrome" (Reaven, 1988), and are associated with increased VAT, rather than SAT (Blackard et al., 1993; Fujioka et al., 1987; Marin et al., 1992). In women, this visceral fat is defined as a waist-to-hip ratio higher than 0,80 centimetres (Hammond, 2000, p. 372). This effect of fat distribution is additive to, and independent of the effect of obesity itself (Evans et al., 1984a).

Fat distribution is affected by a number of conditions, such as gender, aging and ethnicity. Women in general have less central fat than men for a given amount of fatness, and men have about twice as much visceral fat than pre-menopausal women. This difference in genders might be an important contributor to the greater prevalence of diseases associated with central obesity in men compared with pre-menopausal women. Aging in both men and post-menopausal women demonstrates greater accumulation of central fat, particularly VAT. Central fat distribution in obese nondiabetic, pre-menopausal African-Americans seems to be a smaller risk for metabolic abnormalities than in comparably obese Caucasians, and Caucasians have less risk than Japanese-Americans and East-Indians. Different ethnic groups might therefore accumulate abdominal fat differently as they gain weight, with some putting on more VAT, and some putting on more SAT. Further comparative studies between racial groups are however necessary, as few studies using careful measurement of VAT, SAT and total adipose tissue (TAT) in relation to health risks have been done (Pi-Sunyer & Albu, 1999).

Numerous research studies conducted in the 1980's have confirmed earlier speculations that central fat distribution is an important determinant to consider in the association between obesity and disturbances in glucose homeostasis (Kissebah et al., 1982; Kalkhoff et al., 1983; Krotkiewski el al., 1983).

Researchers in Wisconsin (Kissebah et al., 1982; Kalkhoff et al., 1983; Evans et al., 1984a), were the first to classify fat distribution in women according to waist-to-hip circumference. According to the results obtained with their research, the waist-to-hip ratio circumference, a significant predictor of plasma triglyceride, glucose and insulin concentrations, correlated positively with an *in vivo* index of insulin resistance (Kissebah et al., 1982; Kalkhoff et al., 1983; Evans et al., 1984a).

Krotkiewski et al. (1983), found that women with high waist-to-hip ratios were the ones most likely to suffer the metabolic abnormalities of obesity. Kissebah et al. (1982), who took needle biopsy specimens of subcutaneous fat cells from the abdomen and thigh of women, suggested that the abdominal fat cells of women with an android fat distribution were larger and showed a higher rate of lipolysis than those from women with a gynaecoid distribution of fat. The presence of these large fat cells could be an important factor in the susceptability of women to glucose intolerance and hyperinsulinaemia (Kissebah et al., 1982).

The relation between waist-to-hip circumference and metabolic aberrations may depend on the increased accumulation of intra-abdominal fat cells, and the abnormalities might arise from the unique position of these fat cells to the portal circulation (Krotkiewski et al., 1983). The accurate determination of total body fat, both internal and subcutaneous, has become an important issue as it plays a key role in the development of diseases, such as type 2 diabetes (Thomas et al., 1998). Determination of the relationship between central fat distribution, waist-to-hip circumference and other anthropometrically derived variables, are thus of great importance

(Ashwell et al., 1985). Anthropometry can unfortunately only distinguish between android and gynaecoid fat distribution, and not between the intra-abdominal and subcutaneous fat deposits. Computed tomography, providing thin, cross sectional radiographical images that may be obtained at any level in the body, may now be used to assess intra-abdominal fat. This method of determining intra-abdominal fat in patients is however only feasible with small groups of subjects, whereas anthropometry may be used to assess fat distribution in large groups (Ashwell et al., 1985; Thomas et al., 1998). A study conducted by Ashwell et al. (1985), in which both computed tomography and anthropometry were used, indeed demonstrated that "apple-shaped figures" tend to have more intra-abdominal fat than "pear-shaped figures", and that the waist-to-hip circumference ratio correlates significantly with the proportion of intra-abdominal fat, and the ratio of intra-abdominal to subcutaneous fat, but not with the amount of subcutaneous fat (Ashwell et al., 1985).

Although evidence for a strong relationship between chronic diseases and adiposity has traditionally been based on the anthropometric indices of BMI and waist-to-hip ratio (Haffner et al., 1992, Kaye et al., 1991), the use of waist circumference has recently been suggested to be a better indicator of blood pressure and fasting blood glucose than BMI and waist-to-hip ratio, because waist size is a cumulative measurements of the absolute amounts of total and abnormal fat distribution (Okusun et al., 1998). A waist measurement above 88 centimetres in women, is considered to place these individuals at higher risk for developing chronic diseases (James, 2001). According to Okusun et al, (1998), this measurement is more relevant to cardiovascular disease than total body fat (Okusun et al., 1998). When the association between abdominal fat distribution, hypertension and type 2 diabetes were examined, results clearly demonstrated that waist circumference is significantly and independently associated with increased risk of hypertension and diabetes of men and women in African-origin populations from three contrasting environments. A reduction in waist size could therefore lead to a

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reduction in hypertension and diabetes in men and women of these three populations (Okusun et al., 1998).

Magnetic resonance imaging, a fast, reliable, and nonbiased technique, can also be used to determine internal and subcutaneous body fat. Furthermore, this technique can help to determine accurately the impact of genetic and environmental factors on different body fat compartments (Thomas et al., 1998).

Following studies by Peiris et al. (1986, 1987), it was suggested that obesity *per se* is associated with insulin hypersecretion, while upper-body fat accumulation is associated with reduced hepatic insulin extraction and diminished insulin clearance.

Després et al. (1989), studied the association between adipose tissue localization and glucose tolerance in premenopausal obese women. The researchers reported that the amount of deep abdominal body fat, as determined by means of computed tomography, is an important variable to consider in glucose metabolism disturbance associated with obesity and body-fat distribution, with the level of deep abdominal fat displaying the highest association with the glucose area under the curve for the plasma glucose concentration during an oral glucose tolerance test. Deep abdominal fat may therefore be seen as an important correlate of the metabolic disturbances associated with body-fat distribution (Després et al., 1989).

Rebuffé-Scrive et al. (1990), found that subjects with low levels of deep abdominal fat did not display glucose intolerance, and high levels of deep abdominal fat were required to observe the aberrations in glucose metabolism associated with the high adipose tissue mass. In contrast to glucose tolerance, results indicated that there was no correlation with the accumulation of deep abdominal fat and plasma insulin levels and C-peptide areas. It rather appears that the level of

subcutaneous trunk fat and the extent of abdominal fat hypertrophy are important correlates of pancreatic insulin secretion (Rebuffé-Scrive et al., 1990).

Circulating free fatty acids (FFA) released from expanded visceral adipose tissue in obese subjects, seem to play a considerable role in metabolic abberations (Turner & Clapham, 1998). The production of FFA from adipose tissues drained by the portal vein might hypothetically be an important potential trigger for the metabolic derangement and diseases with enlarged intra-abdominal fat depots. The metabolism of these tissues (omental and mesentric) were compared with subcutaneous abdominal and retroperitoneal (nonportal) tissues in abdominally obese men and women. Both men and women had large intra-abdominal adipocytes. It can thus be concluded that intra-abdominal adipose tissue has a pronounced potential to release high concentrations of FFA into the portal. If these FFA levels are increased, it might interfere with hepatic metabolism, with unwanted consequences regarding metabolic aberrations. Portal lipolyses may play a contributing role in generating risk factors for cardiovascular disease and type 2 diabetes (Rebuffé-Scrive et al., 1990).

In a study on 16 men with a wide variation of total body fat, mass, morphology and metabolism of total adipose tissue and its subcutaneous, visceral and retroperitoneal sub-compartments were examined. Several different characteristics of visceral adipose tissue have been indicated by this study. These adipose tissue masses correlated directly with blood glucose, and plasma insulin levels, blood pressure and liver function tests, with correlations strongest with visceral fat mass. Following oral administration of labeled oleic acid in triglyceride, adipose tissue lipid uptake was more rapid in visceral than in subcutaneous adipose tissue. Adipocytes from omental fat showed a higher lipolytic sensitivity, and a lower sensitivity to the antilipolytic effects of insulin. Furthermore, significant correlations were found between total adipose tissue mass and metabolic variables such as blood pressure, blood glucose levels and plasma insulin concentrations. These relationships were stronger with total intra-abdominal adipose tissue, and

for visceral rather than retroperitoneal fat. Insignificant correlations were found with lipid uptake in subcutaneous or retroperitoneal abdominal adipose tissue. The results thus suggest a strong relationship between visceral adipose tissue metabolism on the one hand, and glucose homeostasis, insulin resistance and blood pressure on the other (Marin, 1992).

In a study conducted by Blackard et al. (1993) on morbidly obese subjects, insulin sensitivity of splanchnic versus peripheral adipose tissue was compared, and relative concentrations of the products of lipolysis (free fatty acids and glycerol) in peripheral versus portal blood were determined. They suggested that central obesity is a consequence rather than a cause of insulin resistance. The greater sensitivity of splanchnic adipose tissue may explain some of the epidemiologic observations made in previous studies. The critical question arises whether increased splanchnic adipose tissue plays a role in the pathogenesis of type 2 diabetes by flooding the liver with free fatty acids directly through the portal vein. The researchers however argue that any previous assumptions made that excessive splanchnic fat deposits might result in increased free fatty acid delivery to the liver are invalid, because of an inverse relationship between adipose tissue mass and lipolytic rate expressed per unit of fat mass. An explanation for this inverse relationship between adipose tissue mass and lipolytic rate may be the relative sensitivity of adipose tissue compared with other insulin-responsive tissues. As insulin resistance develops, the greater insulin sensitivity of fat compared with other tissue may result in larger fat deposits with reduced lipolytic rates. The data obtained through this study, provided a likely explanation for the association between hyperinsulinemic insulin-resistant states and increased waist-to-hip ratios (Blackard et al., 1993).

Albu et al. (1999) also determined the role of visceral adipose tissue accumulation in systemic fat metabolism. Nondiabetic, premenopausal obese black and white women differing in their manifestations of upper body obesity, were compared in the above-mentioned study. Systemic glycerol and free fatty acid rates of appearance (RA), were measured in the basal state and

during a pancreatic euglycemic clamp. Basal RA Glycerol, but not RA free fatty acids was lower in black than in white women. During the clamp, black women showed greater insulin suppression of RA Glycerol than of RA free fatty acids, and greater insulin suppression of RA Glycerol, but similar suppression of RA free fatty acids compared with white women. In both races, visceral adipose tissue accumulation was associated with systemic resistance to the antilipolytic effect of insulin. In obese black women, systemic lipolyses measured as glycerol turnover rate was more responsive to insulin suppression than were systemic free fatty acid turnover rates (Albu et al., 1999).

Although some studies have suggested that there is a stronger correlation between insulin resistance and abdominal subcutaneous fat than with intra-abdominal fat, most cross-sectional studies have shown a clear relationship between visceral adiposity, insulin resistance and conditions associated with insulin resistance (glucose intolerance, dyslipidaemia, impaired fibrinolysis and hypertension). Most attention has focussed on the Portal Theory, suggesting that visceral fat delivers fatty acids at a high rate into the portal vein, so that they directly influence hepatic metabolism. This theory is based on many studies, consistently showing visceral fat to be more active metabolically than subcutaneous fat, tending to set fatty acids free more readily. Available evidence *in vivo* does however not lend full support to the Portal Theory, and alternative explanations for the relationship between visceral fat accumulation and insulin resistance (e.g. stress), should therefore also be considered (Frayn, 1999).

Numerous studies have thus been performed in the area of fat distribution and its association with metabolic aberrations. However, limited data exists on the effect of race on these factors, as the bulk of the evidence came from studies performed in white populations (Seidell et al., 1991). Studies amongst black women with a prevalence of obesity exceeding fifty percent, more frequently affected by obesity related diseases and cardiovascular diseases, and with a higher average body mass index (BMI) than their white counterparts need to be undertaken

(Conway et al., 1995).

Suggestions made by Zillikens and Conway (1990), that black women have greater upper-body obesity based on an increased subscapular skinfold thickness as compared with whites, were confirmed in the Coronary Artery Risk Development in Young Adults study (CARDIA). Little is however known about visceral adipose deposition patterns in black women, or the effect of these differences on metabolic variables. Data obtained in a study on visceral adipose tissue differences in black and white women, where fat distribution was determined by using anthropometry and computed tomography, however do not support increased abdominal VAT as explanation for the higher risk for obesity-related morbidity in black women (Conway et al., 1995).

1.3.1.3 AETIOLOGY OF OBESITY

Numerous factors seem to contribute to the occurence of obesity. For the purpose of this study, the following main influences on the equilibrium levels of body fat will be investigated:

Both biological influences and environmental factors are involved in the aetiology of obesity.

i) BIOLOGICAL INFLUENCES

Biological factors involved in the aetiology of obesity include age, gender, genetic and metabolic factors.

a) AGE AND GENDER

It is a well-known fact that fat loss and weight maintenance becomes more difficult with

increasing age (Bourdin et al., 1993). Most people decrease their physical activity considerably with increasing age, but find it difficult to adjust their energy intake accordingly (James, 2001).

Worldwide trends in obesity indicate that this disease is not limited to certain regions, countries or racial groups. Some literature do however show that fat is discriminating, with women at higher risk than men, and black women in poverty at greater risk for obesity than prosperous women (Laquatra, 2000, p. 486). Data from a number of South African studies have revealed that there is a high occurrence of obesity in local African women (Crowther & Van der Merwe, 2001; Kalk, 2001; Mollentze et al., 1995; Walker, 1995b; Steyn et al., 1991), with the proportion of obese black women being double that of white women (Walker, 1995b).

b) GENETIC AND METABOLIC FACTORS

Studies of intake and energy expenditure in humans have implied that obesity is not only caused by bad behaviour or so-called "sloth and gluttony", but that inherited metabolic characteristics together with unfavourable environmental circumstances such as free access to energy-dense food and a lack of physical activity, cause obesity to develop. Even in westernized environments favourable to weight gain, some people will not gain weight, probably as a result of their genetic background (Walker, 1995b; Ravussin, 2000b). A child with one or, worse, two obese parents, is at a considerably increased risk of becoming obese (Walker, 1995b).

Two genes involved in obesity have received considerable attention recently, namely the β3-adrenoreceptor gene and the oh gene (Laquatra, 2000, p. 494). In a study conducted by Mitchell et al. (1998), the effect of the variant Trp64Arg on obesity in Mexican Americans was examined. The β3 adregenic receptor, located on chromosome eight is an important regulator of energy expenditure and lipolysis. A variant in this gene that results in a substitution of tryptophan for arginine at codon 64 (Trp64Arg), associated with obesity and insulin resistance,

has recently been identified. The researchers used a paired sibling design to minimize variability due to genetic background and a previously identified major susceptability locus for obesity. The variant found to be present in one sibling within each of the 45 sib-pairs, was associated with considerably higher values in BMI, fat mass, and waist circumference. Individuals with this Trp64Arg variant were found to be more obese than those without the variant. This was true for nearly all of the obesity phenotypes, indicating the association between the Trp64Arg variant and obesity in this Mexican American population (Mitchell et al., 1998).

The oh gene produces leptin (Laquatra, 2000, p. 493), a hormone secreted by the adipose tissue, that seems to inform the brain about the amount of adipose tissue in the body (Laquatra, 2000, p. 493). The leptin receptor and agouti signaling protein seem to be possible candidate genes in the development of obesity (Ravussin, 2000b). Obese humans produce signifant quantities of leptin. Its concentration is correlated with the percentage of body fat, and is elevated in obese individuals. Weight loss is therefore associated with a reduction in leptin concentrations (Laquatra, 2000, p. 493).

Van der Merwe et al. (1999) investigated the relationship between leptin concentrations, various metabolic indices and body composition. Lipotrophic diabetic patients, normal subjects, white and black obese women, and white and black obese diabetic women formed part of the study group. No positive linear correlations were found between leptin concentrations, BMI, subcutaneous fat mass and free fatty acid levels across the groups. Leptin and free fatty acid concentrations were higher and insulin levels lower in both groups of black women compared to the two groups of white women, despite a similar BMI and body fat mass. It was suggested that the large increase in visceral fat mass in the diabetic black women may be indicative of a more complex relationship between compensatory insulin resistance, elevated free fatty acid levels and leptin secretion (Van der Merwe et al., 1999). The discovery of leptin has been described as a great step forward, but it is doubted whether it is of that much importance in terms of the

everyday problem of obesity, and studies on the gene as such seem to have been overplayed (Walker et al., 1999). Leptin gene abnormalities are rare. It seems however, that many obese humans are resistant to the actions of leptin, because a they are obese in spite of elevated leptin levels (Björntorp, 2001). It has been estimated that genes account for only five percent of BMI and subcutaneous fat, implying that the primary causes of obesity are not genetic (Bouchard, 1991). In a more recent review it was however concluded that a significant part of human obesity, perhaps as much as 79 percent, has a genetic component Van Itallie & Simopoulos 1993, as cited by Walker, 1995b.

Recent other findings suggest that genes contribute to the perceptability for obesity, but are not the actual cause. Other determinants must therefore be present for obesity to occur, of which the environment is a major one (Laquatra, 2000, p. 495). This finding is supported by Walker et al., (1999), who reason that obese individuals cannot be expected to have total self-control over their weight in an environment that promotes weight gain by reinforcing overeating and inactivity any more than they can control their genes (Walker et al., 1999). Furthermore, Eaton et al. (1988) reason that it is improbable that the human gene pool has changed substantially over the last 35 000 years, but we have radically transformed the environment in which we live, particularly in the last century. Eaton et al (1988) proposed the "discordance hypotheses", suggesting that obesity results from a mismatch between modern lifestyle and the lifestyle from which humans, and our genes, evolved.

ii) ENVIRONMENTAL FACTORS

Environmental factors involved in the aetiology of obesity include diet, physical activity, and other factors. Migration studies indicate that the environment plays an important role in obesity. Suggestions have thus been made that environmental factors largely determine the prevalence of obesity among different populations, while among individuals from the same population, living

in a given environment, genetic factors seem to play the dominant role. The staggering increase in obesity in industrialized countries seems to be caused by major changes in environmental factors, such as an increased consumption of fat, low levels of physical activity (Ravussin, 2000a), and overeating in general (Walker et al., 1999). This is also called the "toxic environment" (Battle & Brownell, 1996). Socio-economic status and place of residence are other contributing factors. The environment is therefore to be considered the overwhelming factor in the development of the obesity issue (Walker et al., 1999).

a) DIETARY FACTORS

Basically, a habitual energy intake greater than energy expenditure, promotes obesity (Pi-Sunyer, 1994; Björntorp, 2001). Dietary factors that contribute to obesity have been categorized under two headings. The first group includes those people with eating disorders, in whom weight gain is caused by pathological disturbance in their attitudes towards food. People with binge eating disorders represent the largest single category. All the known single gene disorders of obesity have their effects through a disregulation of appetite rather than expenditure. The second group includes those people whose eating habits are unexceptional, but who constantly consume more energy than they expend (Prentice, 2000b). The popular belief that a diet high in carbohydrate in the form of starch is promotive of obesity, is now considered incorrect, as for traditionally living Africans, a very high consumption of carbohydrate is consistent with no gain of weight with age (Walker, 1995b). A high sugar intake is almost invariably blamed for obesity, but again incorrectly so COMA Report 1990, as cited by Walker, 1995b.

Fat, which is very energy dense (Westrate, 1995), is now regarded as the most important dietary component in the aetiology of obesity (Prentice, 2000b). Cross-sectional studies have also demonstrated that obese subjects viewed as a whole, consume a more fat-rich diet than normal-

weight subjects Astrup et al. 1994, as cited by Walker, 1995b. The obvious choice for reducing total energy to treat or prevent obesity, would therefore be to reduce dietary fat intake. Initial weight loss is normally less than from a conventional low energy diet (Lissner & Heitman, 1995), but in the long term, the reduced fat regimen seems easier to maintain (Lyon et al., 1995).

Concerning other aspects of diet, the practice of snacking, together with excessive television viewing and short sleep duration have often been blamed for obesity Locard et al. 1992, as cited by Walker, 1995b.

Allison and Pi-Sunyer (1994) have emphasized the fact that obese people do eat more than their lean counterparts, and that obese people also regularly underreport their food intake. Non-obese people eat when they are hungry, and stop eating when their hunger subsides. Obese people follow the same pattern, but more food is necessary to reduce hunger. To tell these people to eat only when they feel hungry, may be parallel to telling them to overeat (Allison & Pi-Sunyer, 1994).

b) PHYSICAL ACTIVITY

It is a well-known fact that physical inactivity plays a prominent role in the development of obesity (Walker, 1995b), with sedentary men and women more likely to become overweight than those who are physically active (Blair, 1993; Barlow et al., 1995).

Although the rate of weight loss can be faster with dietary restriction than with any exercise programme (Prentice, 2000b; Blair, 1993), exercise appears to play the more dominant role in terms of long-term weight maintenance (Prentice, 2000b), also reducing waist-to-hip circumference (Blair, 1993). Saris (2000) reported that the human body has a complex and highly sophisticated system for regulating body weight and fat stores, and in this system, regular

physical exercise plays a critical role. Weight reduction studies indicate that a larger percentage of initial weight loss is maintained in subjects who exercise regularly. Physical exercise leads to direct energy expenditure and increased aerobic fitness, thus promoting weight maintenance (Saris, 2000). Indirectly it increases lean body mass (Blair, 1993; Saris, 2000), lipid mobilisation and oxidation. Aerobic exercise can lead to moderate weight and fat loss, while resistance training will increase fat free mass, having little effect on weight itself (Saris, 2000). Obese people are usually unfit, and tend to oxidise less fat at all levels of exercise intensity. Moderately intense physical activity should therefore be recommended for obese people (Egger & Swinburn, 1997).

Programmes designed to address the prevention and management of obesity should therefore focus on the combined role of diet and physical activity (Prentice, 2000b; Saris, 2000).

c) OTHER FACTORS

Obesity is more common among the poor than those better circumstanced with a high level of education Flegal et al. 1988, as cited by Walker, 1995b. It is also strongly believed that communities facing sudden changes in lifestyle and socio-economic status, are at greater risk of developing obesity than traditional communities (King & Rewers, 1991; Seidell, 1999).

Parental neglect during childhood causes an increased risk of obesity in young adulthood, which is independent of age, BMI, sex and social background Lissau & Sorensen 1994, as cited by Walker, 1995b. Furthermore, obesity is twice as common in married as in single men. This is however not the case among women Sobal et al. 1992, as cited by Walker, 1995b.

One unfortunate disadvantage of giving up smoking, is that a gain in weight is experienced. A study conducted on Swedish women demonstrated that an increase in lower body fat, i.e. in the

area not associated with increased cardiovascular disease, was experienced when they stopped smoking Lissner et al. 1992, as cited by Walker, 1995b.

In a study on overweight men in Australia, the combination of reduced alcohol consumption and weight loss from energy restriction led to substantial reductions in blood pressure and improved serum lipid profiles Puddey et al. 1992, as cited by Walker, 1995b. An inverse association has been found between obesity and alcohol consumption in men in the USA. This was not however the case in France and the UK. In women in these three countries, obesity prevalence varied according to their level of exercise, income, and alcohol consumption Laurier et al. 1992, as cited by Walker, 1995b.

1.3.2 CARDIOVASCULAR RELATED DISEASES

Cardiovascular related diseases are multicausal diseases, accelerated by a westernized diet and lifestyle.

1.3.2.1 CORONARY ARTERY DISEASE

According to Steyn et al. 1992, as cited by Derman, Derman & Noakes, 1995, coronary artery disease (CAD) contributes largely to the burden of morbidity and mortality from chronic diseases in industrialized countries, including South Africa. Increasing urbanization and the adoption of Western lifestyles and dietary habits seem to play the major role in the development of these diseases (Seedat et al., 1982). Following a study by Mollentze et al. (1995) to determine and compare the prevalence of ischaemic heart disease risk factors in a rural and urban black population, the researchers concluded that "all the elements for a potential epidemic of atherosclerotic cardiovascular disease in decades to come, are present in these populations" (Mollentze et al., 1995).

1.3.2.2 HYPERTENSION

Hypertension is currently clinically the single, most prevalent cardiovascular disease in rural as well as urban adult black South Africans (Mollentze et al., 1995). Hypertension, obesity and diabetes mellitus are not only common, but also interrelated medical problems in Westernized, industrialized societies, with approximately thirty to forty million people suffering from hypertension, 25 million people having diabetes mellitus, and nearly 3 million estimated to have both these diseases. These groups share some common pathogenic mechanisms. Hypertension is associated with insulin resistance and type 2 diabetes mellitus (Bakris et al., 1996; Haffner, 1997), while obesity enhances the development of type 2 diabetes mellitus and hypertension. The hypertensive diabetic is at greater risk for developing cerebrovascular, peripheral vascular and cardiovascular complications. Insulin resistance and central obesity, amongst others, increases the risk for atherosclerosis, while end-stage renal disease is almost always present in the hypertensive diabetic (Bakris et al., 1996). Hypertension is virtually absent in very lean rural African populations, but is very common in predominantly obese Westernized black populations (Bunker et al., 1995).

According to Poulter et al. 1990, as cited by Opie, 1995, urbanization leads to an increase in dietary salt intake, a decrease in potassium intake and weight gain, and subjects experience urbanization as extremely stressful.

The Australian Aborigines, as well as other previously traditional societies now in transition to an urbanized Westernized existence, currently experience very high rates of type 2 diabetes mellitus and its complications, as well as hypertension and cardiovascular disease, or the so-called "New World Syndrome". Circulatory diseases are now the number one cause of death in male and female Aborigines. These diseases are largely attributed to lifestyle factors (Gracey, 1995).

1.3.2.3 STROKE

Stroke, a disease of the twentieth century, is the third most common cause of death in the USA. Risk factors for stroke include old age, hypertension, tobacco smoking, coronary heart disease, atrial fibrillation, diabetes and overnutrition (Shiveley & Connolly, 2000, p. 946). According to Bradshaw et al. (1995), stroke has the highest mortality in urban black South Africans, followed by hypertension, type 2 diabetes, and ischaemic heart disease, while in white and Asian South Africans, ischaemic heart disease has the highest mortality, followed by stroke, type 2 diabetes and hypertension.

1.3.3 CANCER

Cancer is regarded as a disease caused by gradual damage to the DNA of the body's cells (Frankmann, 2000). According to Sitas & Norman (1995) most cancers are related to social conditions, such as residence, work and lifestyle. According to Van Rensburg et al. 1985, as cited by Sitas & Norman, 1995, migration of most households of the rural African population of South Africa to cities to seek external sources of income, resulting in lifestyle changes, is bound to influence the prevalence of cancers in this population. Traditional foods have now been replaced by Western eating, smoking and drinking patterns. The typical Western diet high in fat, and low in fibre, is related to a high incidence of colon, pancreas, breast, prostate, ovary and endometrial cancer. The replacement of this diet with an increased intake of vegetables and fruit, can decrease the risk for several types of cancer (Weisburger, 1991).

According to Sitas & Norman (1995), the ten leading cancers in South Africa are oesophageal cancer, cervical cancer, skin cancer, lung cancer, breast cancer, liver cancer, prostate cancer, colorectal cancer, bladder cancer, and stomach cancer. It is estimated that eighty to ninety

percent of cancer is related to environmental factors, including an estimated 35 percent that are diet related (Frankmann, 2000, p. 868).

1.4 PROBLEM STATEMENT

It is assumed that westernisation and urbanisation has had a negative effect on the nutritional health, specifically an increased risk for developing type 2 diabetes mellitus, of black women (25 – 44 years) in the Mangaung area. Mangaung is an urban area situated in Bloemfontein where changes in diet and activity patterns with resulting increases in diseases of lifestyle, such as type 2 Diabetes Mellitus, have most likely occurred. This makes Mangaung an ideal area to study the impact of changing eating patterns and lifestyle. A study of this nature is essential to understanding the association between lifestyle and health status and can make an important contribution to the science of nutrition in developing countries.

1.5 OBJECTIVES

The following main objectives and sub-aims were set for this study:

1.5.1 MAIN OBJECTIVE

The main objective of the study was to determine the relationship between anthropometry, dietary intake and risk for developing type 2 diabetes mellitus in women (25-44 years) living in Mangaung.

1.5.2 SUB-AIMS NECESSARY TO ACHIEVE THE MAIN OBJECTIVE

1.5.2.1. To determine the anthropometric status of women.

1.5.2.2. To determine the dietary intake of women.

1.5.2.3. To determine the prevalence and risk for developing type 2 diabetes mellitus.

1.5.2.4. To determine associations between anthropometric status, dietary intake and risk for developing type 2 diabetes mellitus.

1.6 OUTLINE OF DISSERTATION:

Chapter 1: Introduction and motivation for the study (problem statement)

Chapter 2: Literature review: Type 2 diabetes mellitus

Chapter 3: Literature review: Anthropometry

Chapter 4: Methodology

Chapter 5: Results

Chapter 6 Discussion of results

Chapter 7: Conclusions and recommendations

1.7 SUMMARY

Similar to some other countries, South Africa is in many ways a country in transition, currently experiencing political, demographic, social, economical, and nutritional changes. These transitions have lead to a number of changes in peoples lives, such as changes in economic status, lifestyle and eating habits. The abandoning of the traditional diet for a more westernized diet, a lack of physical activity, and other factors, play a significant role in the development of chronic diseases of lifestyle, such as type 2 diabetes mellitus, obesity, cancer and cardiovascular diseases.

CHAPTER 2

TYPE 2 DIABETES MELLITUS

2.1 INTRODUCTION

Diabetes mellitus has been described as a group of diseases characterized by high blood glucose levels resulting from defects in insulin secretion, insulin action, or both, with abnormalities in the metabolism of carbohydrates, fats and proteins also being present. The body of the diabetic person does not produce or respond to insulin, a hormone produced by the β cells of the pancreas that is necessary for the use or storage of body fuels. Without effective insulin, hyperglycemia occurs, which can lead to both the short-term and long-term complications of diabetes mellitus (Franz, 2000, p. 743).

Insulin resistance is an impaired biologic response to either exogenous or endogenous insulin. Insulin resistance and insulin deficiencies are usual causes of type 2 diabetes (Franz, 2000, p. 743).

Glucose homeostasis represents the dynamic balance between glucose absorption, glucose production and glucose utilization. Normal blood glucose concentrations are maintained by the complex interaction between circulating metabolic hormones (insulin, glucagon, catecholamines, growth hormone, glucocorticoids, glucoincretins) and cellular proteins involved in insulin signalling, glucose uptake and glucose disposal. Three factors mainly determine normal glucose homeostasis. These include the insulin secretory capacity of the pancreas in response to a glucose load, the ability of insulin to suppress hepatic glucose production, and the responsiveness of skeletal muscle and liver to insulin stimulated glucose uptake (Turner & Clapham, 1998).

Table 2.1 represents the classification and diagnosis of diabetes mellitus.

Table 2.1 Types of diabetes and impaired glucose homeostasis (Adapted from Franz, 2000, p. 745).

CLASSIFICATION	DISTINGUISHING CHARACTERISTICS
Type 1 diabetes	Affected persons usually are lean, have abrupt onset of symptoms before the age of thirty years (although it may occur at any age), and are dependent on exogenous insulin to prevent ketoacidosis and death. This condition was previously called insulin-dependent diabetes mellitus (IDDM) or juvenile-onset diabetes.
Type 2 diabetes	Affected persons usually are obese and are older than thirty years of age at diagnosis. Although not dependent on exogenous insulin for survival, individuals may require insulin for adequate glycemic control. This condition was previously known as non-insulin-dependent diabetes mellitus (NIDDM), or adult-onset diabetes.
Gestational diabetes mellitus (GDM)	A condition of glucose intolerance affecting pregnant women, the onset or discovery of which, occurs during pregnancy.
Other specific types	Diabetes that results from specific genetic syndromes, surgery, drugs, malnutrition, infections, and other illnesses.
Impaired glucose homeostasis	Metabolic stages of impaired glucose homeostasis (impaired fasting glucose or impaired glucose tolerance) that are intermediate between normal glucose values and diabetes.

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Impaired glucose homeostasis	Metabolic stages of impaired glucose homeostasis (impaired fasting glucose or impaired glucose tolerance) that are intermediate between normal glucose values and diabetes.

According to Pickup (1991), diabetes mellitus is currently considered as the most common metabolic disorder worldwide. This disease was virtually unknown among the Pima Indians when they lived as subsistence farmers a hundred years ago (Hrdlicka, 1908; Russell, 1975). In 1978, the prevalence of type 2 diabetes mellitus in the Pimas had been reported to be as high as fifty percent in adults over 35 years of age (Knowler et al., 1978), with one of the features associated with this dramatic increase being a change from a traditional diet high in complex carbohydrates and dietary fibre, to a diet high in fat (Reid et al., 1971).

The prevalence of type 2 diabetes has increased in the early part of the 20th century, particularly in developing countries. There is now evidence that the prevalence also continues to increase in developed countries including the United States (Burke et al., 1999, Warram et al., 1997).

While for many years considered a disease associated with the affluent, resulting from an over-indulgent life-style (Haffner, 1998), type 2 diabetes is now considered a Third World problem, with glucose intolerance reaching its greatest frequency in developing countries and the disadvantaged in industrialized countries (Haffner, 1998; King & Rewers, 1991). This disease now also occurs at a younger age in developing populations (Vaughan et al., 1989), with weight gain after the age of 18 a strong determinant for the onset of type 2 diabetes mellitus (Colditz et al., 1995).

Diabetes mellitus affects approximately 16 million Americans, with type 2 diabetes mellitus accounting for ninety to 95 percent of diagnosed cases. Approximately 5,4 million people with diabetes, have remained undiagnosed (Franz, 2000, p. 743). Type 2 diabetes also occurs commonly in the South African population, with indications of an increase in black South Africans (Walker & Walker, 1991). It has been projected that the number of diabetics worldwide will increase from 135 million in 1995 to 3000 million in 2025 (Seidell, 1999), with increases of 42 percent in developed countries, and 170 percent in developing countries (King et al., 1998).

Death rates from hypertension and type 2 diabetes mellitus are six to eight times higher in developing countries (McLarty et al., 1996). This represents a major health concern for emerging nations where health services are still burdened with infectious diseases. These nations now have to face the additional burden of chronic diseases (Prentice, 1997). For the purpose of this study, special attention will be given to type 2 diabetes mellitus.

2.2 PREVALENCE OF TYPE 2 DIABETES MELLITUS IN SOUTH AFRICA

A few studies on the prevalence of type 2 diabetes in African South Africans have been performed. Levitt et al. (1993), studied the prevalence in urban Africans in the greater Cape Town area, and reported an eight percent prevalence of type 2 diabetes, and seven percent for impaired glucose tolerance, after being age-adjusted (Levitt et al., 1993).

According to findings by Mollentze et al. (as cited by Levitt & Mollentze, 1995) in a study comparing the prevalence of type 2 diabetes in an urban Free State African population (Mangaung), with that of QwaQwa, a partly rural population, the prevalence of diabetes was six percent and 4,8 percent respectively, and the prevalence of impaired glucose tolerance 12,2 percent and 10,7 percent respectively.

2.3 AETIOLOGY OF TYPE 2 DIABETES MELLITUS

It is obvious from numerous previous research studies that type 2 diabetes mellitus does not have one single causal factor. Various determinants contribute to the development of this disease, and furthermore, these determinants are also closely interlinked.

Type 2 diabetes mellitus is characterised by impaired β-cell function, and increased insulin resistance (Crowther & Van der Merwe, 2001).

Fujimoto (1996), suggested that the following factors are fundamentally important for the pathogenesis and aetiology of type 2 diabetes:

- Both insulin resistance and an islet beta cell lesion adversely affecting insulin production and secretion.
- Development of insulin resistance facilitates the emergence of the beta cell lesion.
- Central adiposity is related to insulin resistance.
- Both heredity and environment are involved in the aetiology of type 2 diabetes.

Insulin resistance refers to an impaired biologic response to either exogenous or endogenous insulin. Insulin resistance and insulin deficiencies are usual causes of type 2 diabetes (Franz, 2000, p. 743). Insulin resistance, existing in both hepatic and peripheral tissues, is an early defect, and present in most individuals with impaired glucose tolerance, and all patients with type 2 diabetes with a fasting blood glucose level above 8 mmol/l (ADA, 1988).

According to Franz (2000, p. 748), the first defect that influences the development of type 2 diabetes, is an abnormal insulin secretion pattern, that can be either excessive or inadequate. Insulin is released by the pancreas in two phases, and in persons with type 2 diabetes, the initial sharp acute release of insulin does not appear. Secondly, uptake of glucose at cellular level may decrease. This resistance to insulin may result from either a cellular receptor or a postreceptor defect. Finally, release of glucose by the liver in the early morning hours may increase, as reflected by an elevation in fasting blood glucose levels (Franz, 2000, p. 748).

The action of insulin involves two processes: insulin binds to a specific receptor located on the cell surface, and the binding of insulin to the receptor activates a series of intracellular events, namely enhanced glucose transport, and stimulation of some intracellular enzymatic pathways. Abnormalities in these events are primarily responsible for insulin resistance (ADA, 1988).

Normal insulin secretion takes place in two phases, namely the early phase which occurs within thirty minutes after glucose ingestion, representing the release of insulin stored within the β-cell, and a later phase that includes newly synthesized insulin. When the fasting blood glucose exceeds 6,4 mmol/l, the early phase secretion is diminished, and the second phase secretion remains normal, or more often is increased, resulting in hyperinsulinaemia. The increased secretion of insulin does not decrease the blood glucose level, due to insulin resistance at tissue level. The resultant hyperglycemia is toxic to the β-cell which leads to a decrease in insulin production. The decrease of insulin in the portal vein does not suppress hepatic glucose production, leading to excessive hyperglycaemia (ADA, 1988).

Type 2 diabetes mellitus is an important health problem in the African population of Southern Africa, but it is still unknown whether the primary cause is insulin secretory dysfunction, or peripheral insulin resistance. Joffe et al. (1992), proposed that in this population group, there is an initial reduction of β-cell mass, followed by an accelerated phase of β-cell decompensation, induced by a variable period of peripheral insulin resistance, leading ultimately to insulinopenic type 2 diabetes (Joffe et al., 1992). A low birth weight in babies, associated with poor fetal nutrition, and adult obesity, both commonly appearing in the South African black population, may also be associated with glucose intolerance (Crowther & Van der Merwe, 2001).

African-Americans and African South Africans with type 2 diabetes share some unusual clinical features, which can be related to progressive β-cell failure, but African-Americans also encompass a major insulin-resistant variant (Joffe et al., 1996).

In a prospective study of South African Indians with impaired glucose tolerance, the results indicated that impaired glucose tolerance in these subjects is characterized predominantly by impaired β-cell function and insulin deficiency (Motala & Omar, 1993).

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In another South African study, insulin receptor binding characteristics of urbanized African women with normal glucose tolerance, and patients with newly diagnosed untreated type 2 diabetes was evaluated. Four groups of ten subjects each were selected as follows: group A, young (20-39 years) nonobese (BMI 19,0-24,9 kg/m^2) nondiabetic women; group B, middle-aged (40-60 years) nonobese, nondiabetic women; group C, middle-aged obese (BMI >30,0 kg/m^2) nondiabetic women; and group D, middle-aged obese newly diagnosed but untreated female patients with type 2 diabetes. Results showed decreasing insulin-receptor activity with obesity and glucose intolerance. In patients with type 2 diabetes, hyperglycemia and beta cell dysfunction were associated with a reduction in receptor concentration (Panz et al., 1992).

The metabolic syndrome therefore represents a vicious circle, with insulin resistance leading to hyperinsulinemia, which maintains normal plasma glucose, but may lead to hypertension, dislipidemia and atherosclerosis, and may disturb insulin resistance leading to further hyperinsulinemia. Excess insulin secretion may eventually reduce the function of the beta cell due to amyloid deposition, which will lead to raised blood glucose and further deterioration of beta cell function and insulin sensitivity (Wolever, 1999).

Results from a study by O'Dea et al. (1990), support results of other studies in that hyperinsulinemia is also associated with impaired glucose tolerance, elevated triglycerides and lower high-density lipoprotein cholesterol levels (O'Dea et al., 1990).

The results of a study of insulin resistance conducted in Pima Indians, also clearly demonstrated the relationship between impaired glucose tolerance and the development of this disease (Lilioja, et al., 1993). Both insulin resistance and impaired insulin secretion are required to manifest the disease (Eriksson et al., 1989; Groop, 1999).

A recent study conducted on the effect of fatty acids on insulin secretion, confirmed that a glucose fatty acid cycle is operative in pancreatic β cells. High levels of free fatty acids (non-esterified fatty acids / NEFA) are already known for their stimulating effect on insulin secretion from β-cells of the pancreas. Effects of chronically high levels of NEFA occuring in type 2 diabetes, however needed further investigation. The hypothesis that fatty acids could in the long term have a more negative than positive effect on insulin secretion have therefore been tested *ex vitro* in rats, after a 48 hour infusion with Intralipid. Inhibitory effects on glucose-induced insulin secretion were demonstrated. The conclusion was made that enhanced fatty acid oxidation brought about by elevated NEFA was responsible for the negative effects on insulin secretion and glucose metabolism (Grill & Qvigstad, 1999).

The role of the pancreatic islet β-cell therefore seems to be critically important in the pathogenesis of type 2 diabetes. Lifestyle factors, obesity and physical inactivity increase the risk for hyperinsulinaemia, accompanied by insulin resistance in the muscle and liver. Insulin production by the β-cells become unable to compensate for the increased resistance, and impaired glucose tolerance develops (Fujimoto, 1996).

2.4 RISK FACTORS FOR THE DEVELOPMENT OF TYPE 2 DIABETES

Risk factors for the onset of Type 2 diabetes mellitus have been examined in many populations. In general, factors such as aging, gender (Franz, 2000, pp. 745, 748; Stern et al., 1984), a family history of diabetes (Franz, 2000, p. 745), obesity (Franz, 2000, p. 745; Bakris, 1996; Dowse et al., 1991), a prior history of gestational diabetes, impaired glucose homeostasis, physical inactivity (Franz, 2000, p. 745; Salmeron et al., 1997), race or ethnicity (Franz, 2000, p. 745), socio economic status (Stern et al., 1984) and westernization (Fujimuto, 1996) are associated with impaired glucose tolerance and type 2 diabetes mellitus. Smoking, diet and alcohol consumption are also now receiving attention as possible risk factors (Salmeron et al., 1997).

Apart from the above-mentioned factors, previous investigations have shown that hypertension, angina and elevated cholesterol levels are more prevalent in subjects with impaired glucose tolerance than in subjects with normal glucose tolerance (Haffner, 1998).

2.4.1 AGING

Older age is probably one of the most powerful risk factors associated with type 2 diabetes (Franz, 2000, p. 743; ADA, 1988). About fifty percent of cases occur in people older than 55 years of age (Franz, 2000, p. 743).

According to Seedat & Mayet (as cited by Levitt & Mollentze, 1995), age emerged as the strongest risk factor for diabetes, and the only significant independent risk factor for impaired glucose tolerance in a study performed on Indians and Africans in Natal.

2.4.2 GENDER

The prevalence of type 2 diabetes is slightly higher in women than in men, especially in African-American women (Franz, 2000, p. 744).

In South Africa, a study was undertaken to assess the prevalence of type 2 diabetes mellitus in an urban Zulu population residing in Umlazi, a township on the outskirts of Durban. It was found that type 2 diabetes mellitus was more common in women than in men, while impaired glucose tolerance was more common in men than in women. Of the female diabetic subjects, 64,7 percent were obese, and of the male diabetic subjects, 66,7 percent were obese. Based on the results of this study, it would appear that a rising BMI and obesity constitute important risk factors in the emergence of diabetes among black women. The researchers concluded that if type 2 diabetes mellitus is categorized as a disease of urbanization and modernization, such a

trend would certainly be true of South African Zulus who have become urbanized over the past few decades (Omar et al, 1993).

2.4.3 GENETIC FACTORS

Although the causes of Type 2 diabetes remain poorly understood, there is overwhelming evidence that genetic susceptibility contributes strongly to its development (Turner & Clapham, 1998).

Mexican-Americans, living in the same neighborhood as non-Hispanic whites, showed a higher prevalence of type 2 diabetes, indicating that there may indeed be some genetic factors involved in the development of diabetes within this population (Stern et al., 1984).

A history of type 2 diabetes mellitus in first-degree relatives is also associated with an increased risk of having diabetes (Newman et al., 1987; ADA, 1988), and the concordance for type 2 diabetes between identical twins is sixty to ninety percent (Newman et al., 1987).

Groop et al. (1993b) investigated the association between polymorphism of the glycogen synthase gene and type 2 diabetes. These researchers came to the conclusion that the A2 allele of the human glycogen synthase gene on chromosome 19 identifies a sub-group of patients with type 2 diabetes with a strong family history of type 2 diabetes, and in whom hypertension and insulin resistance are prevalent, thus considering the A2 allele a genetic marker for type 2 diabetes (Groop et al., 1993b).

Although the appearance of type 2 diabetes in certain families and ethnic groups show a strong genetic background, these genes need be unmasked by environmental factors, such as obesity and a sedentary life style, predisposing to insulin resistance and type 2 diabetes (Groop, 1999).

After examining data from epidemiologic studies in Mexican Americans, Haffner (1998), suggested that a combination of genetic and cultural effects result in obesity and an unfavourable body fat distribution, which lead to insulin resistance. In addition, direct genetic influences may also predispose this population to insulin resistance. In response to insulin resistance, the pancreatic islets initiate a prolonged period of insulin hypersecretion, which produces β-cell exhaustion, ultimately resulting in type 2 diabetes (Haffner, 1998).

The role of the pancreatic islet beta cell is of critical importance in the pathogenesis of type 2 diabetes mellitus, with proinsulin a possible marker for a primary beta-cell lesion in this pathogenesis (Kahn et al., 1995). As long as the beta cell can compensate for the degree of insulin resistance, glucose tolerance remains normal (Groop, 1999). Impaired insulin-stimulated glucose metabolism in skeletal muscle represents key features of type 2 diabetes and are observed early in the pre diabetic state. The question whether these defects represent inherited muscle defects, or whether they develop secondarily to abdominal obesity, should be asked. The findings that abdominal obesity and a low metabolic rate seem to precede the development of insulin resistance in offspring of type 2 diabetics, are in favour of the last hypothesis. The "thrifty gene" hypothesis states that individuals living in an environment where food supply is unstable, could, by maximizing storage of surplus energy, maximize their probability of survival. When this energy storing genotype is exposed to the abundance of food typical of westernized societies, it causes insulin resistance, and consequently type 2 diabetes. The candidate gene approach or the random gene search are the two major approaches used in the search for these "thrifty genes". Attractive candidate genes are the ones regulating lipolyses, and genes involved in the regulation of the insulin signaling cascade and glycogen synthesis in skeletal muscle. The random gene search has so far provided one locus with significant linkage to an insulin-resistant phenotype, namely chromosome 2 q in Mexican Americans. Type 2 diabetes obviously develops as the consequence of a collision between "thrifty genes" and an affluent environment (Groop, 1999).

A study to identify early metabolic defects in subjects at increased risk for developing type 2 diabetes, was undertaken by Eriksson et al. (1989). These researchers measured sensitivity to insulin and insulin secretion in first-degree relatives of patients with type 2 diabetes, and compared them with patients with type 2 diabetes, and healthy control subjects with no family history of type 2 diabetes. The conclusion was made that impaired glucose metabolism is common in the first-degree relatives of patients with type 2 diabetes, and that both insulin resistance and impaired insulin secretion are necessary for the development of impaired glucose tolerance in these subjects (Eriksson et al., 1989). These findings further highlight the fact that type 2 diabetes has a strong genetic background.

Despite overwhelming evidence that genetic factors strongly contribute to the development of type 2 diabetes, the mode of inheritance and the genetic loci still remain largely unknown (Turner & Clapham, 1998).

2.4.4 ETHNIC AND RACIAL FACTORS

Epidemiologic studies have demonstrated a greater tendency for developing type 2 diabetes in certain ethnic and racial populations (Haffner et al., 1997). In South Africa, the Indian population is at greater risk for developing type 2 diabetes (ADA, 1988). Remarkable world-wide differences exist in the prevalence of this disease (Fujimoto, 1996), with numbers ranging from virtually zero percent in Papua, New Guinea, to over fifty percent in the Pimas of Arizona (King & Rewers, 1993), thus supporting the fact that certain population groups seem to be at greater risk of developing this desease. These differences among ethnic groups can be attributed to differences in genetic predisposition, for example insulin resistance, which seems to be the most significant predisposing factor for type 2 diabetes in various ethnic groups (Haffner et al., 1990).

A significant secular trend in the incidence of type 2 diabetes mellitus was also observed in Mexican Americans and in non-Hispanic whites who returned for a seven to eight year follow-up examination in the San Antonio Heart study. Results indicated that the incidence for type 2 diabetes mellitus has approximately tripled in both ethnic groups (Burke et al., 1999). It is therefore obvious that there are ethnic differences in the risk for diabetes (King & Rewers, 1993).

When the impact of race and positive family history of type 2 diabetes on glucose/insulin dynamics and the two components of glucose disposal was examined, non-diabetic black Americans manifested insulin resistance and hyperinsulinemia, irrespective of family history of type 2 diabetes when compared to white people. These metabolic changes could play a potential role in the higher prevalence of type 2 diabetes in black Americans (Osei & Cottrell, 1994).

Contrary to other reports, Haffner et al. (1997), found that a small proportion of subjects with type 2 diabetes with normal BMI in the U.S. are insulin sensitive, and that this proportion does not vary widely by ethnic group. These results were very similar, even in newly diagnosed type 2 diabetic subjects. In nonobese type 2 diabetics, few subjects were shown to be insulin sensitive.

2.4.5 ENVIRONMENTAL AND SOCIO-ECONOMIC FACTORS

Environmental factors contributing to the increase in type 2 diabetes mellitus may include either qualitative or quantitative alterations in diet, changes in the degree of physical activity, stress-related phenomena and westernization (Zimmet, 1982; Fujimoto, 1996, Seidell, 1999; Stern et al., 1984; Leonetti et al., 1994).

Notable rural-urban and native-migrant differences exist in the appearance of this disease, e.g. between Polynesians in rural and urban Western Samoa, between Chinese in China and Mauritius, and between Asian Indians in rural India and Fiji, with urbanization and migration increasing this risk (King & Rewers, 1993; Fujimoto, 1996; Seidell, 1999; Stern et al., 1984).

The diet of rural Zulu women differs considerably from that of urban Zulu women, with the rural diet comprised of 69 percent carbohydrate, 17 percent fat, 13 percent protein and 37 gram fibre per day, compared with fifty percent carbohydrate, 31 percent fat, 16 percent protein and 14 gram per day fibre in the diet of urban Zulu women (Albertse et al., 1990). This places the urban women at higher risk for developing type 2 diabetes.

Animal fat intake and physical inactivity may be related to the development of glucose intolerance and visceral adiposity (Leonetti et al., 1994). Cholesterol levels above 5,5 mmol/l and triglyceride levels above 2 mmol/l accompanied by hypertension or significant hyperlipidemia, are also considered a major risk for type 2 diabetes (ADA, 1988). Diets ranking low on the glycemic index have recently been observed to have a short-term favourable effect on whole-body insulin sensitivity in people with diabetes, coronary heart disease and obesity (Frost et al., 1998; Salmeron et al., 1997), and should therefore be promoted amongst diabetics.

The effect of short-term exercise was examined over a period of seven days in insulin sensitive, obese, hypertensive African-American women. The results obtained, support the debate that recent exercise can have a substantial impact on glucose and insulin metabolism. An improvement of 58 eight percent in insulin sensitivity, and twenty percent and 25 percent reductions in fasting and glucose-stimulated plasma levels were reported. These improvements were independent of changes in fitness levels, body composition or body weight (Brown et al., 1997).

In Cape Town, the African population has shown substantial growth over the past years, resulting in the rapid development of new townships. Following a research study amongst these urban Africans above thirty years of age, urbanization has been identified as a significant independent risk factor for type 2 diabetes mellitus, with this disease rising substantially after twenty years of urban residence (Levitt et al., 1993).

Data on the prevalence of type 2 diabetes mellitus in African blacks based on the revised World Health Organisation criteria have however been described as scanty (Omar et al., 1993), and with the changing sociodemographic picture, the local data need to be updated (Levitt et al., 1993).

Type 2 diabetes is more common amongst men in the low and middle socio-economic group, with a gradual decline in prevalence for women from the lowest to the highest socio-economic group (Stern et al., 1984). Studies of the prevalence of type 2 diabetes mellitus in Mexican Americans and non-Hispanic whites in San Antonio have also pointed out that there is a relationship between socio-economic status and the prevalence of diabetes. Furthermore, this relationship has been observed in most developed countries (Stern et al., 1984).

In a more recent study, the relationship between socio-economic status and cardiovascular disease risk factors i.e. syndrome X, in a genetically enriched African-American population at increased risk for type 2 diabetes, was examined. In contrast to the above, results showed no effect of socio-economic factors on cardiovascular disease or syndrome X in this high risk population group. The researchers concluded that the conventional risk factors for cardiovascular disease in genetically enriched African-Americans are found in individuals with the highest insulin levels, independent of socio-economic status (Gaillard et al., 1997).

2.4.6 THE ASSOCIATION BETWEEN OBESITY AND TYPE 2 DIABETES MELLITUS

In chapter 1 an overview of obesity has been given. A clear association exists between obesity and type 2 diabetes mellitus.

Central obesity is associated with a greater risk for type 2 diabetes mellitus (Levitt et al., 1993), because of its effect on insulin sensitivity (Pi-Sunyer & Albu, 1999). When the Australian Aboriginal people made the transition from a traditional to an urbanized lifestyle, they developed high rates of obesity, particularly central obesity, type 2 diabetes mellitus, cardiovascular and renal disease. Remaining lean, however protected these people from conditions such as type 2 diabetes, hypertension, dyslipidaemia and albuminuria (Rowley et al., 1997). A study conducted on type 2 diabetic African-American men with a mean BMI of approximately 26,5 kg/m^2 showed a strong correlation between insulin resistance and visceral or central fat distribution, with little or no correlation between BMI and insulin resistance (Banerji et al., 1995). The strikingly high prevalence of type 2 diabetes in a small Aboriginal community in Northern Australia, despite the population being relatively lean, may also be ascribed to a central pattern of fat distribution (O'Dea et al., 1990). When obesity as a metabolic risk factor is considered, body fat distribution should therefore also be taken into account, with visceral fat increasing the risk of developing diabetes (Fujimoto, 1996).

The higher prevalence of overweight amongst African-American and Hispanic women explains why this portion of the American population is more prone to the development of type 2 diabetes mellitus than non-Hispanic white women (Haffner, 1987; Stevens et al., 1992). Although obesity is strongly related with type 2 diabetes in individuals who are particularly prone to gaining large amounts of weight, obesity *per se* is a weak discriminator between those who will develop type 2 diabetes, and those who will not (Warrem et al., 1997). When obesity as a metabolic risk factor

is considered, body fat distribution should be taken into account, with visceral fat increasing the risk of developing diabetes (Fujimoto, 1996).

2.4.7 INSULIN RESISTANCE AND GLUCOSE INTOLERANCE

Although the cause of insulin resistance is still unknown, factors at jeopardy include free fatty acids, tumour necrosis factor, α-leptin, hyperglycaemia, glucosamine, calpain-10, down-regulation of insulin receptor numbers, and function, and reduced glucose transporter and glycogen synthase activity (Crowther & Van der Merwe, 2001).

In recent years, increasing attention has highlighted the association between insulin concentrations and various metabolic disorders including hypertension, dyslipidemia and glucose intolerance (Groop et al., 1993a). The clustering of insulin resistance with hypertension, glucose intolerance, hyperinsulinemia, increased triglyceride and decreased high-density lipoprotein cholesterol levels, and central and overall obesity, has been called syndrome X, or the insulin resistance syndrome (Reaven, 1988). This hypothesis was tested by means of the factor analysis method by Meigs et al. (1997). Factor analysis is a statistical technique that should identify one factor, if a single process underlies the clustering of these risk variables. The results were consistent with more than one independent physiological process underlying risk variable clustering: a central metabolic syndrome (characterized by hyperinsulinemia, dyslipidemia and obesity), glucose intolerance, and hypertension. Glucose intolerance and hypertension were linked to the central syndrome through shared correlations with insulin levels and obesity. Insulin resistance alone did not appear to underlie all features of the insulin resistance syndrome (Meigs et al., 1997).

Accumulating evidence suggests that impaired glucose tolerance is a stage in the development of type 2 diabetes. Risk factors and risk markers such as obesity, family history of type 2

diabetes, physical inactivity, hypertension, angina and elevated total cholesterol levels, are more prevalent in subjects with impaired glucose tolerance than in subjects with normal glucose tolerance. Progression from normal glucose tolerance to type 2 diabetes may occur via a number of steps, with genetic factors being the primary basis. Hyperinsulinemia, accompanied by insulin resistance, develops under pressure of lifestyle factors such as obesity and physical inactivity. Insulin production by the beta cells becomes unable to compensate for this insulin resistance, and impaired glucose tolerance develops. Damage to the beta cells then causes a decline in insulin secretion and fasting hyperglycemia, typical of type 2 diabetes. If this hypothesis is correct, impaired glucose tolerance can be described as an intermediate stage in the development of type 2 diabetes (Harris, 1996).

2.5 HEALTH COMPLICATIONS

The major threat to life and health of those suffering from type 2 diabetes, is progressive retinopathy causing blindness, nephropathy causing renal failure, coronary heart disease, peripheral vascular disease, cerebrovascular disease, neuropathy causing nerve damage (Franz, 2000, p. 762; WHO, 1991), perinatal mortality, and congenital abnormalities (WHO, 1991). The increase in morbidity and mortality due to these complications, places a heavy financial load on health services (Musaiger, 1992), and should therefore be addressed on a national scale.

2.6 SUMMARY

Type 2 diabetes mellitus is considered a Third World problem, affecting increasing numbers of people in developed and developing countries, including South Africa, where type 2 diabetes is an important health problem amongst the African population.

Type 2 diabetes mellitus, which affects people above the age of thirty, is characterised by insulin resistance, a dysfunction of the insulin secreting β cells of the pancreas, and reduced receptor binding characteristics, leading to high blood glucose levels, and metabolic abberations.

Risk factors for the onset of this disease, include aging and gender, with people above the age of 55 years, and women, at higher risk for developing type 2 diabetes. The appearance of type 2 diabetes in certain families and ethnic groups show that genetic factors play a role in the appearance of this disease. This area however needs further investigation. Certain ethnic populations, including the South African Indian population, show a greater tendency for the development of type 2 diabetes. Migration and urbanisation, characteristised by a change in life-style factors, including diet and physical activity play a role in unmasking type 2 diabetes. Men in lower and middle income groups are at greater risk for developing type 2 diabetes, showing that socio-economic factors play a further contributing role in the appearance of this disease. Obesity, characterised by a high BMI, and particularly central obesity, seem to be major contributing factors towards the development of type 2 diabetes. The association between insulin concentrations and various metabolic disorders, known as Syndrome X, is currently receiving increased attention as factors contributing to the development of type 2 diabetes.

Type 2 diabetes, which is associated with a number of serious health complications, including retinopathy, neuropathy, renal failure, and cardiovascular diseases, needs urgent attention to relieve the financial burden placed on the health services of many developing and developed countries.

CHAPTER 3

ASSESSMENT OF NUTRITIONAL STATUS

3.1 INTRODUCTION

Nutritional status can be assessed by various methods (Hammond, 2000, p. 358) namely:

- medical, social, medication and nutritional histories
- physical examination
- anthropometric data
- laboratory data

For the purpose of this study, anthropometric data and dietary intake data will be discussed.

3.2 ANTHROPOMETRY

Measurement of the body's dimensions and composition, which is indispensable to the practice of nutrition assessment, is an area of considerable current interest to both scientists and the public (Lee & Nieman, 1996, p. 224).

Anthropometry involves obtaining physical measurements of an individual, and relating these measurements to standards that reflect, amongst others, their health- and nutritional status (Lee & Nieman, 1996, p. 224; Gibson, 1998, p. 427), such as obesity (Lee & Nieman, 1996, p. 224). The most commonly used measurements are height, weight, skinfold thickness and other girth measurements. These parameters are affected by ethnic, familial, and environmental factors, which should be taken into account when anthropometric measurements are evaluated (Hammond, 2000, p. 368).

Anthropometric assessment has the advantage that the procedures used are safe, and non-invasive, applicable to large sample groups; the equipment required is inexpensive, portable, and durable; relatively unskilled personnel can perform the measurements, the methods are exact and accurate if standardized procedures are used; information on past long-term nutritional history is obtained with equal confidence using other techniques; and the procedures can help to identify mild to moderate malnutrition, as well as severe malnutrition (Gibson, 1998, p. 427).

3.2.1 HEIGHT AND WEIGHT

Both height and weight, which can be measured in various ways, are useful in determining nutritional status in adults (Pressman & Adams, 1990, p. 46; Hammond, 2000, p. 369; Gibson, 1998, pp. 427-428). Stature or standing height can be measured for subjects who are able to stand without assistance, and can be measured in several ways (Lee & Nieman, 1996, p. 225). The simplest method that can be used, is to fasten a measuring stick or nonstretchable tape measure to a flat, vertical surface, for example a wall without a skirting, with the subject not standing on carpet. A right-angled headboard is used for reading the measurement (Lee & Nieman, 1996, p. 225).

Another approach is to use a stadiometer. When this method is used, the subject should stand barefoot on a flat surface (Pressman & Adams, 1990, p. 46), and wearing minimal clothing, to facilitate correct positioning of the body. The subject should stand with heels together, arms to the side, legs straight, shoulders relaxed, and head in the Frankfort horizontal plane (looking straight ahead) (Pressman & Adams, 1990, p. 46; Lee & Nieman, 1996, p. 225). Heels, buttocks, scapulae and the back of the head should be against the vertical board of the stadiometer. Just before the measurement is taken, the subject should inhale deeply, hold the breath, and maintain an erect posture, while the headboard is lowered upon the highest point of

the head with enough pressure to compress the hair. The measurement should be read to the nearest 0,1 cm, with the eye level with the headboard to avoid errors due to parallax (Lee & Nieman, 1996, pp. 225-226).

Body weight, providing a crude evaluation of overall fat and muscle stores, is considered as one of the most important measurements in nutritional assessment (Lee & Nieman, 1996, p. 227). Body weight may be interpreted by various methods, including ideal weight for height, usual weight and actual weight. Ideal weight for height can be calculated from reference standards such as the Metropolitan Life Insurance Tables (Hammond, 2000, p. 369), or the National Centre for Health Statistics (NCHS) medians which are convenient, quick, and easy to use (Lee & Nieman, 1996, p. 233).

Usual body weight compares the present weight of the individual to usual body weight, therefore allowing changes in body weight to be assessed (Hammond, 2000, p. 370). Actual body weight refers to weight measurement obtained at the time of examination. Changes in the individual's fluid status may influence this measurement (Hammond, 2000, pp. 369-370).

A balance-beam scale (Lee & Nieman, 1996, p. 228; Pressman & Adams, 1990, p. 46; Gibson, 1998, p. 429), with nondetachable weights, or an electronic scale can be used to obtain body weight. Scales must be placed on a flat, hard surface, and the zero weight on the scale's horizontal beam should be checked periodically after the scale has been moved. Minimal underclothing or an examination gown can be worn by subjects to be weighed (Pressman & Adams, 1990, p. 46; Lee & Nieman, 1996, p. 229). The subject should stand in the middle of the scale's platform without touching anything, and with the body weight distributed on both feet. The weight is then read to the nearest 0,1 kg (Lee & Nieman, 1996, p. 228).

3.2.2 BODY MASS INDEX

Body mass index (BMI) accounts for differences in body composition by defining the level of adiposity according to the relationship of weight to height, thus eliminating dependence on frame size. This index has the least correlation with body height and the highest correlation with independent measures of body fatness for adults (Hammond, 2000, p. 370).

Body mass index is measured as W/H^2, in which W is weight in kilograms and H is height in square meters (Pressman & Adams, 1990, p. 46; Hammond, 2000, p. 370). A BMI of 20 to 25 is associated with the least risk of early death. The classification of BMI is represented in Table 3.1.

Table 3.1: Classification of BMI (Laquatra, 2000, p. 493).

Underweight	<18,5
Normal	18,5-24,9
Overweight	25,0-29,9
Obesity, class I	30,0-34,9
Obesity, class II	35,0-39,9
Extreme obesity, class III	≥ 40

3.2.3 BODY COMPOSITION

Interest in human body composition has grown over the past decades, mainly because obesity has been associated with such diseases as type 2 diabetes mellitus, hypertension, and coronary heart disease (Lee & Nieman, 1996, p. 224).

Body composition has been defined as the ratio of fat to fat-free mass (Lee & Nieman, 1996, p. 247; Gibson, 1998, p. 431), the latter referring to tissue devoid of all extractable fat (Laquatra, 2000, p. 487), and frequently is expressed as a percentage of body fat. These two body compartments can be indirectly assessed by anthropometric techniques, and variations in their amount and proportion can be used as indices of nutritional status (Gibson, 1998, p. 431).

Body weight variations among individuals of similar height can be ascribed to differences in the skeletal size and the proportion of lean body mass (Hammond, 2000, p. 371), the latter referring to the total of all body components except storage lipid and bone (Laquatra, 2000, p.487). Muscular athletes, for example, may be classified as overweight because of excess muscle mass rather than adipose mass (Hammond, 2000, p. 371).

Body composition can be determined by means of skinfold thicknesses, bioelectrical impedance, and other methods.

3.2.3.1 SKINFOLD THICKNESS (SUBCUTANEOUS FAT)

The most widely used method of indirectly assessing the amount of body fat of an individual, is to measure skinfolds – the thickness of a double fold of skin and compressed subcutaneous adipose tissue (Lee & Nieman, 1996, p. 249; Gibson, 1998, p. 432). This method is performed by using a skinfold caliper, which measures the thickness of subcutaneous fat tissue in millimeters, giving a rough measurement of adiposity. This measurement bases total body fat estimates on the assumption that fifty percent of body fat is subcutaneous. Accuracy however decreases with an increase in adiposity (Hammond, 2000, p. 371).

Although more accurate methods for assessing percent body fat exist, skinfold measurement has the following advantages: the equipment needed is inexpensive, and requires little space;

measurements are easy and quickly obtained; and when correctly done, skinfold measurement provides estimates of body composition that correlates well with those derived from hydrostatic weighing, the most widely used laboratory method for determining body composition (Lee & Nieman, 1996, p. 249).

Because thickness of subcutaneous adipose tissue varies widely among different skinfold sites within individuals, and for the same skinfold site between individuals, overall subcutaneous adipose tissue is best assessed by measuring multiple skinfold sites. A minimum of three different sites is recommended (Lee & Nieman, 1993, p. 137-138). Skinfold sites identified as most reflective of body fatness are over the triceps and the biceps, below the scapula, above the iliac crest and on the upper thigh (Hammond, 2000, p. 371).

The triceps is the most commonly measured site, because of its accessability (Lee & Nieman, 1996, p. 253), and because it is assumed to be most representative of the whole of the subcutaneous fat layer (Gibson, 1998, p. 432). The triceps skinfold site is on the posterior aspect of the right arm, over the triceps muscle, midway between the lateral projection of the acromion process of the scapula and the interior margin of the olecranon process of the ulna. (Pressman & Adams, 1990, p. 50; Lee & Nieman, 1996, pp. 253-254; Gibson, 1998, p. 432). The patient should stand or sit erect with arm and shoulder bare, and the arm held vertically, not resting on any surface. Ideally, the measurement should be taken three times for correctness (Pressman & Adams, 1990, p. 50).

The biceps skinfold is measured as the thickness of a vertical fold on the front of the left arm above the centre of the cubital fossa (Gibson, 1998, p. 432). The suprailiac skinfold is measured just below and literally to the inferior angle of the left scapula, with the shoulder and arm relaxed (Gibson, 1998, p. 432).

The subscapular site is one cm below the lowest or inferior angle of the scapula. The long axis of the skinfold is on a 45-degree angle directed down and to the right side. The suprailiac skinfold is measured just above the iliac crest at the midaxillary line. The long axis follows the natural cleavage lines of the skin and runs diagonally (Lee & Nieman, 1993, pp. 140; Pressman & Adams, 1990, p. 52; Gibson, 1998, p. 432).

The site where the thigh skinfold measurement is taken, is a vertical skinfold along the midline of the anterior aspect of the thigh, midway between the junction of the midline and the inguinal crease and the proximal border of the patella or knee cap (Lee & Nieman, 1993, pp. 140-142).

3.2.3.2 BIOELECTRICAL IMPEDANCE

Bioelectrical impedance analysis (BIA) is used for body fat analysis. This technique is based on the principal that, compared to fatty tissue, lean tissue has a higher electrical conductivity and lower impedance, relative to water, based on electrolyte content. With this method, four electrodes are attached to the extremities of a patient, after which a small electrical current is passed through the electrodes to obtain electrical and resistance measurements. The current is harmless, and cannot be felt by the subject (Hammond, 2000, p. 373; Lee & Nieman, 1996, p. 272; Pressman & Adams, 1990, p. 52). The reliability of measurements may be influenced by fever, electrolyte imbalance, obesity, the hydration status of the patient (Hammond, 2000, p. 373), ascites and heart failure (Pressman & Adams, 1990, p. 61). Dehydration due to insufficient water intake, excessive perspiration, heavy exercise, or caffeine or alcohol use will result in overestimation of fat mass. To prevent this, subjects are advised to refrain from consuming caffeine and alcohol the day before testing, and avoid heavy exercise 12 hours before testing. One of the primary weaknesses of BIA, is estimating fat-free mass and percent of body fat from the value for total body water (TBW) using regression equations for calculating fat-free mass and percent body fat, because the method is only as good as the equation used.

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BIA has demonstrated good reliability (Pressman & Adams, 1990, p. 63; Lee & Nieman, 1996, p. 273), and when compared with estimates of percent body fat derived from underwater weighing, BIA showed to be as good as, if not slightly better than skinfold measurements in predicting percent body fat. The method is also safe and comfortable for the patient, and the measuring instrument is convenient to use (Pressman & Adams, 1990, p. 63; Lee & Nieman, 1996, p. 273), portable, quick and noninvasive. The instrument is however expensive, and accuracy is affected by the presence of the physical conditions described above (Lee & Nieman, 1996, p. 273; Pressman & Adams, 1990, p. 63).

3.2.3.3 OTHER METHODS

Other methods that can be used to determine body composition include densitometry, total body water, total body potassium, neutron activation analysis, creatinine excretion, 3-Methylhistidine, total body electrical conductivity, infrared interactance, ultrasound, computed tomography, and magnetic resonance imaging.

3.2.4 WAIST-TO-HIP CIRCUMFERENCE RATIO (WHR)

Determining the ratio of the waist or abdominal circumference to the hip or gluteal circumference, is an easy way to assess body fat distribution. The waist-to-hip ratio (WHR) provides an index of regional body fat distribution, and is a valuable guide in assessing health risk (Lee & Nieman, 1996, p. 245). This method differentiates between android and gynoid obesity, and is the most frequently method used to measure adiposity. A WHR ≥1,0 in men or ≥ 0,8 in women is indicative of android obesity, and seen as increasing the risk for obesity-related diseases. Plastic or steel measuring tapes may be used to determine these measurements (Hammond, 2000, p. 372). The waist circumference is measured at the most narrow area below the rib cage and above the umbilicus as viewed from the front. The subject, dressed in light

underwear and a gown, stands erect, abdominal muscles relaxed, arms at the side, and feet together. The measurer then places the tape measure in a horizontal plane, and measures the area of least circumference. The measurement is taken at the end of a normal expiration. The hip circumference is the point of greatest circumference around the hips with the subject in a upright position. The tape is placed in a horizontal plane around the hips at the point of greatest circumference, and the measurement should be taken with the tape in close contact with the skin, but without indenting the soft tissues. The measurement should be recorded to the nearest 0,1 cm. The WHR is calculated by dividing the waist circumference by the hip circumference (Lee & Nieman, 1996, p. 245).

3.3 DIETARY INTAKE

The purpose of dietary assessment is to estimate food consumption or nutrient intake in individuals or groups of people (Nelson, 2000, p. 315), and is probably the most widely used indirect indicator of nutritional status. Although it may appear to be fairly easy and straight forward to the uninitiated, estimating an individual's usual dietary and nutrient intake is difficult. Weaknesses in data-collection techniques, human behaviour, the natural tendency of the individual's nutrient intake to vary considerably from day to day, and the limitations of nutrient composition tables and databases, makes this indeed a very complicated task. Furthermore, various methods for collecting food consumption data exist (Lee & Nieman, 1996, p. 91), with no single method being perfect (Lee & Nieman, 1996, p 92; Dwyer, 1998, p. 937). The validity and reliability of these methods depend on the skill of the interviewer, the instruction, training, and cooperation of the subject, and a valid, reliable nutrient database or other system of analysis (Dwyer, 1998, p. 937). Despite these weaknesses, nutrient intake data are valuable in assessing nutritional status when used in combination with biochemical, anthropometric, and clinical data (Lee & Nieman, 1996, p. 91; Dwyer, 1998, p. 937).

Before undertaking dietary assessment, the exact purpose of the assessment needs to be considered; what is to be measured, in whom, over what time period, and how the measurements are to be collected. This will determine the most appropriate technique for a given purpose, and avoid wasting resources using a technique that does not provide an appropriate measure (Nelson, 2000, p. 315).

Two main approaches are used to individual dietary assessment namely prospective and retrospective. Prospective methods involve collecting current dietary data, while retrospective methods require subjects to recall either recent or past diet (Nelson, 2000, p. 316).

When dietary surveys are undertaken, the question whether we really measure what people eat, arises. When assessing the relationship between dietary intake and chronic diseases, accurate assessment of intake is a prerequisite (Livingstone, 1995). No single method of dietary assessment can however be described as perfect (Lee & Nieman, 1996, p 92; Dwyer, 1998, p. 937), and most methods have rarely been fully and independently validated because of the absence of techniques to verify dietary survey methodology. A validation study has nevertheless become a regular part of dietary surveys, and it is generally assumed that once such a study is carried out and published, this is a justification for using the method (Livingstone, 1995).

Validity refers to the degree to which the dietary assessment method used, actually reflects the usual dietary intake (Hammond, 2000, p. 367; Lee & Nieman, 1996, p. 116; Coates & Monteilh, 1997). Validating therefore involves comparing measurements of intake obtained by a specific method, with a subject's usual intake. Because it is very difficult if not impossible to know a person's true usual intake, investigators must turn to relative or criterion validity. The latter can be defined as the comparison of a new instrument with another that has a greater degree of demonstrated or face validity (Lee & Nieman, 1996, p. 116). Several factors can have an effect

on the validity of a measuring instrument. Among these are persons who may consciously or unconsciously change their usual intake when attention is focused on his or her diet (Hammond, 2000, p. 368). These altered food intake patterns may be performed to simplify recording, or to impress the interviewer, therefore decreasing validity of the obtained data. Another problem with these methods of data collection is that people tend to forget what they have actually eaten (Hammond, 2000, p. 368).

Reproducibility or reliability can be defined as the ability of a method to produce the same estimate on two or more different occasions, assuming that nothing has changed in the interim (Hammond, 2000, p. 368; Lee & Nieman, 1996, p. 123; Coates & Monteilh, 1997). Reproducibility does not however necessarily indicate whether the answer is correct. Reproducibility studies can partially answer the validity question. A method cannot give a correct answer every time, unless it gives approximately the same answer every time (Lee & Nieman, 1996, p. 123). Factors such as memory lapses, inaccurate knowledge of portion sizes, and overestimation and underestimation of the amounts of food consumed may negatively influence the reliability of any food intake method (Hammond, 2000, p. 368).

3.3.1. FOOD FREQUENCY QUESTIONAIRE (FFQ)

FFQ are pre-printed lists of foods on which subjects are asked to indicate the typical frequency of consumption, and to state in household measures the average amount consumed on the days when the food is consumed (Nelson, 2000, p. 320). The FFQ or checklist, assesses energy and/or nutrient intake by determining the frequency of consumption of a limited number of foods known to be major sources of the dietary components in question (Lee & Nieman, 1996, p. 100). It is a retrospective review of intake frequency, that is, by food consumed per day, per week, per month (Dwyer, 1998, p. 942; Hammond, 2000, p.366) or per year (Lee & Nieman, 1996, p. 100; Dwyer, 1998, p. 942; Pressman & Adams, 1990, p. 37). FFQ are good to use for describing

intake of groups rather than for individuals (Dwyer, 1998, p. 945), and are commonly used in epidemiological research on diet and disease (Willett, 1990). The food frequency chart arranges foods into groups (Hammond, 2000, p.366) of a hundred or fewer individual foods or food groups that are important contributors to the population's intake of energy and nutrients (Lee & Nieman, 1996, p. 100). In some FFQ, a choice of portion size is not given, and standard portion sizes drawn from large-population data, are used. In other FFQ, subjects may be allowed to indicate whether their usual portion sizes are small, medium or large, with respect to a stated standard portion for certain age/sex groups. Portion sizes are then entered into a computer database, to arrive at the estimated nutrient intake. Some FFQ have been designed to assess intake of individual nutrients or food components (Dwyer, 1998, p. 945), such as vitamin A, fat, or calcium, for studies investigating the relationships between diet and conditions such as cancer (Lee & Nieman, 1996, p. 101). FFQ can therefore vary in length, ranging from very short (nine food items for assessing intake of a single nutrient), to very long and complex (276 items for a national study of diet and heart disease), (Nelson, 2000, p. 320). Specific FFQ have also been developed for certain ethnic groups (Dwyer, 1998, p. 945).

Advantages of this questionnaire include ease in standardization. It can be beneficial when considered in combination with usual food intake and it provides an overall picture of food intake (Dwyer, 1998, p. 943; Hammond, 2000, p. 369), which may be more representative of the usual intake of the individual than a few days of diet records. Furthermore, it can be self-administered (Lee & Nieman, 1996, p. 106; Dwyer, 1998, p. 943; Nelson, 2000, p. 320). However, the data quality is slightly better when the questionnaire is administered by a trained interviewer (Lee & Nieman, 1996, p. 106). This method is also relatively inexpensive for large sample sizes. The design can be based on large-population data, and it is a suitable method to choose for research on diet-disease relationships (Lee & Nieman, 1996, p. 107; Dwyer, 1998, p. 943) on both the macronutrient and micronutrient levels (Lee & Nieman, 1996, p. 107). Reported frequency of food use obtained by FFQ has been shown to be reasonably accurate and valid (Lee & Nieman,

1996, p. 106), and it correlates highly with 7-day weighed records (Pressman & Adams, 1990, p. 38). Although it takes time to develop and validate (Nelson, 2000, p. 321), the FFQ is quick to administer (Lee & Nieman, 1996, p. 106; Dwyer, 1998, p. 943; Pressman & Adams, 1990, p. 38), with no observer necessary (Dwyer, 1998, p. 943).

There are however a few limitations. Response rates may be lower if the questionnaire is self-administered, and incomplete responses may be given (Dwyer, 1998, p. 943). It requires literacy skills if self-administered, does not provide meal pattern data and requires knowledge of portion sizes (Hammond, 2000, p. 369). It may also not represent usual foods or portion sizes chosen by respondents. Intake data can be compromised when multiple foods are grouped within single listings (Lee & Nieman, 1996, p. 107; Dwyer, 1998, p. 943), and the successful administering depends on the ability of the subject to describe his/her diet (Lee & Nieman, 1996, p. 107; Pressman & Adams, 1990, p. 38). Because not all foods can be included in lists, total consumption is difficult to obtain, and underestimation can occur. The burden on the respondent also rises as the number of food items queried increases. Analysis is difficult without use of computers and special programs. Reliability is lower for individual foods than for food groups. Over- and underreporting of foods may occur, and each questionnaire needs validation. (Dwyer, 1998, p. 943).

3.3.2 24-HOUR RECALL

With this method, a trained interviewer asks the subject to recall in detail all the food and drinks consumed during a period of time in the recent past (Lee & Nieman, 1996, p. 97; Dwyer, 1998, p. 942). In most cases the time period recalled consists of the previous 24 hours (Lee & Nieman, 1996, p. 97; Hammond, 2000, p. 366; Dwyer, 1998, p. 942; Nelson, 2000, p. 319). The 24-Hour recall can be obtained on single or multiple occasions (Dwyer, 1998, p. 942). The interviewer assists the respondent in estimating portion sizes of foods consumed and leads the

respondent to recall food and drinks consumed. After the interview, the recall is checked for omissions and/or mistakes, food items are coded individually, and entered into the database for analysis (Lee & Nieman, 1996, p. 97).

The 24-hour recall is considered a quick, easy (Nelson, 2000, p. 319; Hammond, 2000 p. 369; Lee & Nieman, 1996, p. 98; Dwyer, 1998, p. 943), and relatively inexpensive method of data collection regarding food consumption (Lee & Nieman, 1996, p. 98; Dwyer, 1998, p. 943; Pressman & Adams, 1990, p. 34). Subject motivation is less of a barrier, and compliance is good (Nelson, 2000, p. 319; Pressman & Adams, 1990, p. 34). Detailed information about food intake can be provided (Lee & Nieman, 1996, p. 99). No long-term memory is required, and it can be used to estimate nutrient intakes of food groups. Furthermore, it is a more objective method to use than the diet history, and the respondent does not alter the usual diet (Lee & Nieman, 1996, p. 99; Dwyer, 1998, p. 943). The burden on the respondent is also low, data obtained can be repeated with reasonable accuracy, and good reliability exists between interviewers (Dwyer, 1998, p. 943). The method is also suitable to use with illiterate subjects and the aged, except when memory is a severely limiting factor (Pressman & Adams, 1990, p. 34).

Problems such as an inability to recall accurately the kinds and amounts of food eaten, difficulty in determining whether the day being recalled represents the individual's typical intake, and the tendency for persons to over-report low intakes and to under-report high intakes of foods may be encountered with this method (Dwyer, 1998, p. 943; Hammond, 2000, p. 369; Lee & Nieman, 1996, p. 99; Pressman & Adams, 1990, p. 36). Lack of knowledge of portion sizes may create problems, and an experienced interviewer is required (Hammond, 2000, p. 369). This method does not reflect differences in intake for weekday versus weekend, season to season, or shift to shift (Dwyer, 1998, p. 943). Furthermore, this method is time-consuming, and requires certain skills from the interviewer (Pressman & Adams, 1990, p. 36).

The primary limitation of this method is that data on a single-day's diet, no matter how accurate, are a very poor descriptor of an individual's usual nutrient intake, because of day-to-day or intraindividual variability. Multiple 24-hour recalls performed on an individual, and spaced over various seasons may provide a more reasonable estimate of the persons usual intake (Lee & Nieman, 1996, p. 98; Dwyer, 1998, p. 945; Nelson, 2000, p. 319). A cross-check, in which both the food frequency questionnaire and the 24-hour recall questionnaire are used, is also recommended to improve the accuracy of data obtained (Hammond, 2000 p. 369).

3.3.3 DAILY FOOD RECORD / DIARY

In this method, the subject records, at the time of consumption, the identity and amounts of all foods and beverages consumed (Lee & Nieman, 1996, p. 99; Hammond, 2000, p. 363) for a period ranging from one to seven days (Lee & Nieman, 1996, p. 99; Pressman & Adams, 1990, p. 34), or three to seven days (Hammond, 2000, p. 363).

Food and drink intake can be quantitated by estimating portion sizes, using household measures, also called the estimated food record, or by weighing the food and beverages on scales (Lee & Nieman, 1996, p. 99; Nelson, 2000, p. 318; Pressman & Adams, 1990, p. 34), also referred to as a weighed food record. The main advantages of the weighed record is the accuracy of measurement of portion sizes, and the ability to vary the length of the record to suit the requirements of the survey (Nelson, 2000, p. 318). The degree of accuracy with the first method appears acceptable for most research purposes, especially when considering whether subjects will adhere to the program if they have to weigh everything that they consume (Nelson, 2000, p. 318; Lee & Nieman, 1996, p. 99).

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Other strengths of this method are that it provides a daily record of food consumption (Hammond, 2000, p. 369) that does not depend on memory (Lee & Nieman, 1996, p. 99; Dwyer, 1998, p. 944). It can provide detailed intake data, and it can provide data about the respondents eating habits (Lee & Nieman, 1996, p. 99), thus including data on the quantity of food, how prepared, and timing of meals and snacks (Hammond, 2000, p. 369). Data from a multiple-day food record would also be more representative of usual intake than single-day data, either from a 24-hour recall or a 1-day food record. Multiple food records from nonconsecutive, random days, including weekends, covering different seasons are necessary to arrive at useful estimates of usual intake. The method is reasonably valid up to five days (Lee & Nieman, 1996, p. 101), and recording error can be minimized if subjects are given proper directions (Dwyer, 1998, p. 944). The food record is considered most accurate if the food consumed is documented immediately after consumption (Pressman & Adams, 1990, p. 34), or on the same day, where-after nutrient intake is calculated, averaged, and compared with Recommended Dietary Allowances (Hammond, 2000, p. 363). The weighed food diary is considered more accurate than the estimated food record (Dwyer, 1998, p. 944). This method also facilitates comparisons between studies using the same method, because it has been widely used (Nelson, 2000, p. 318). Furthermore, the method is performed in a short time, at low cost, and is easy to record, even by subjects eating in restaurants (Pressman & Adams, 1990, p. 34).

It has the same disadvantages as the estimated food record. Additionally, it requires highly motivated respondents to maintain the diary, scales are not highly portable, and may also cause technical problems (Dwyer, 1998, p. 944), and items such as salad dressings and gravies are commonly omitted (Pressman & Adams, 1990, p. 34). Not all subjects are equally literate (Hammond, 2000, p. 369; Lee & Nieman, 1996, p. 100; Dwyer, 1998, p. 944), and the method requires a high degree of cooperation from the subject (Lee & Nieman, 1996, p. 100; Dwyer, 1998, p. 944). The ability to measure / judge portion sizes (Hammond, 2000, p. 369; Dwyer, 1998, p. 944), and actual food intake may possibly be influenced by the recording process

(Hammond, 2000, p. 369; Lee & Nieman, 1996, p. 100; Dwyer, 1998, p. 944), thus questioning the reliability of records. It also takes more time to obtain the data (Lee & Nieman, 1996, p. 101). Other limitations such as the respondent not recording intakes on assigned days, men not being as competent as women, checking and coding records in a standardised way, and high costs of coding and analysis, exist (Dwyer, 1998, p. 944).

3.3.4 DIETARY HISTORY

Diet history is used to assess an individual's usual patterns of food intake and the food selection variables that dictate food intake (Hammond, 2000, p. 365; Lee & Nieman, 1996, p. 107; Dwyer, 1998, p. 942) over an extended period of time, such as the past month or year (Lee & Nieman, 1996, p. 107; Nelson, 2000, p. 319).

Information about the number of meals eaten per day, appetite, food dislikes, the presence or absence of nausea and vomiting, use of nutritional supplements, cigarette smoking, habits related to sleep, rest, work and exercise etc. are obtained during an interview by a trained nutritionist. This is followed by a 24-hour recall during which information is also obtained about the subject's usual pattern of eating during and between meals (Lee & Nieman, 1996, p. 107; Nelson, 2000, p. 319). Data is then cross-checked. Finally, the subject has to complete a 3-day food record, which serves as an additional way of checking the usual intake (Lee & Nieman, 1996, p. 107).

The principal advantage of this method is the quantity of information about eating habits which can be obtained from a single interview (Nelson, 2000, p. 319). It further has the advantage that it assesses the subject's usual nutrient intake, including seasonal differences (Nelson, 2000, p. 319; Lee & Nieman, 1996, p. 108; Dwyer, 1998, p. 943), and data on all the nutrients can be obtained. It correlates well with biochemical measures (Lee & Nieman, 1996, p.108), and provides a more complete and detailed description of food intake than food records, 24-hour

recalls, or FFQ. Furthermore, it eliminates individual day-to-day variations (Dwyer, 1998, p. 943).

Limitations of this method include an interview of one to two hours by a highly trained interviewer (Nelson, 2000, p. 319; Lee & Nieman, 1996, p. 108; Dwyer, 1998, p. 943), depending on the subject's memory (Dwyer, 1998, p. 943). Furthermore it is difficult to standardize between interviewers (Dwyer, 1998, p. 943), and difficult and expensive to code (Lee & Nieman, 1996, p. 108). Nutrient intake tends to be overestimated (Lee & Nieman, 1996, p. 108; Dwyer, 1998, p. 943), and a cooperative respondent with the ability to recall the usual diet is required (Lee & Nieman, 1996, p. 108).

3.3.5 OTHER METHODS

Other methods used to determine dietary intake, include duplicate food collections, food accounts, food balance sheets, telephone interviews, visual records, computerized techniques, surrogate sources, direct observation by trained interviewers, and food checklists.

3.4 SUMMARY

Anthropometry, which is the measurement of the body's dimensions and composition, may be measured by determining height and weight, BMI, body composition, (which can be determined by measuring subcutaneous fat, bioelectrical impedance, and other methods. These methods were used in this study due to the ease of measurement, relative short period required to determine, measurements, and their accuracy.

Dietary assessment, used to estimate food consumption or nutrient intake, may be determined by means of various methods, including a food frequency questionnaire, 24-hour, recall, daily

food record / diary, dietary history, and other methods. The FFQ used in this study has been shown to be relatively inexpensive to provide an overall picture of food intake in large groups, and it is considered a suitable method for research on diet-disease relationships.

CHAPTER 4

EXPERIMENTAL PROCEDURE

4.1 INTRODUCTION

The increasing rate of urbanization, accompanied by the abandoning of the more healthy traditional diet for a Western diet, have lead to the increase in chronic diseases of lifestyle in many countries. This trend is also experienced in Mangaung, the African residential area of Bloemfontein, and has lead to the urgent need to identify the current extent of chronic diseases of lifestyle, such as type 2 diabetes.

The following framework (Figure 4.1) was compiled for the purpose of this study, to describe the experimental procedures for determining the relationship between anthropometry, dietary intake and risk for type 2 diabetes mellitus in women in Mangaung.

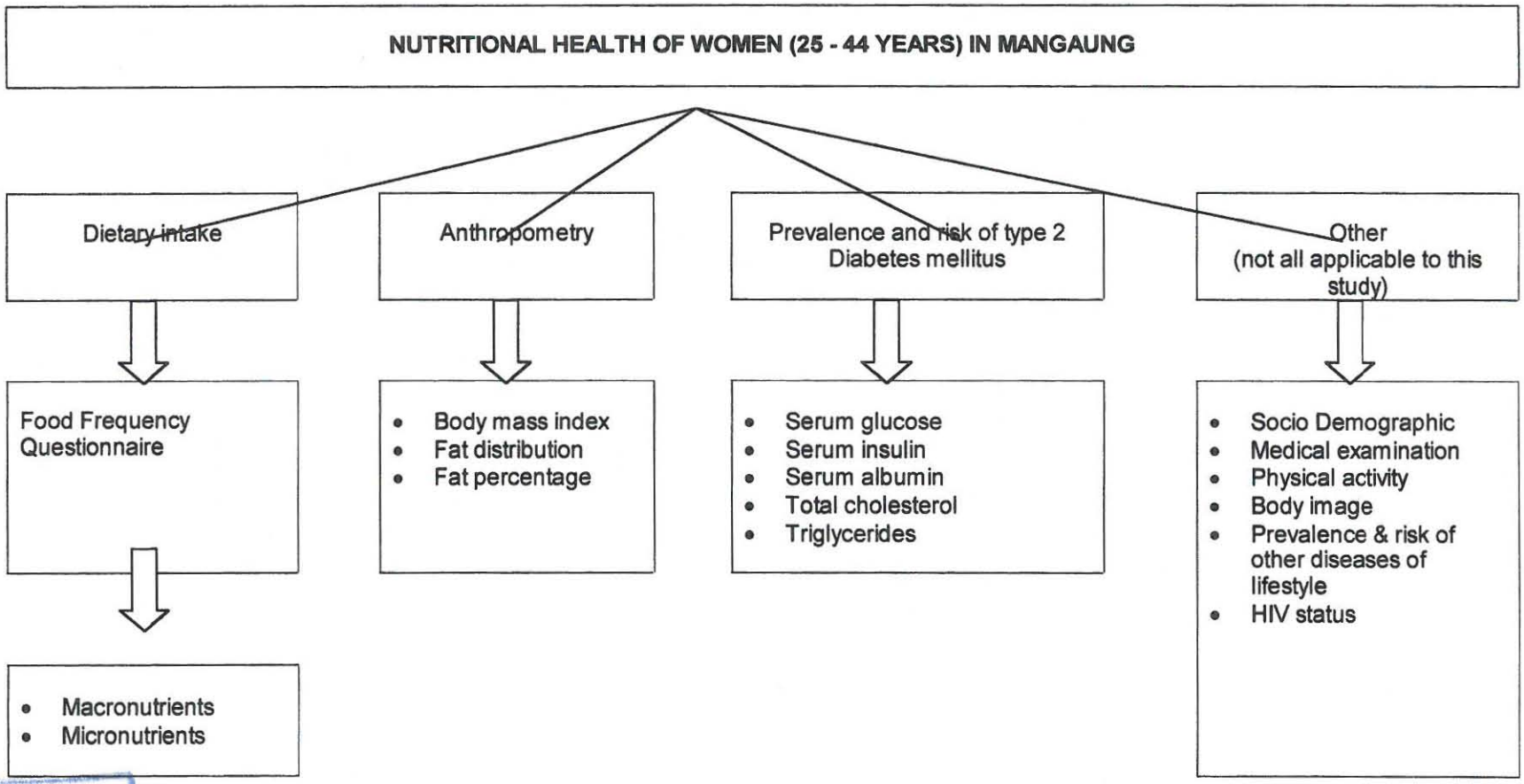

Figure 4.1: Study Framework to determine the relationship between anthropometry, dietary intake and type 2 diabetes mellitus in women (25-44 years) in Mangaung

The study formed part of a larger study investigating the nutritional health of women in Mangaung. The larger study investigated the prevalence and risk of diseases of lifestyle, including obesity, hypertension, type 2 diabetes, cancer risk, fibrinogen status, iron status and HIV status.

The following information was collected:

- Socio-demographic status
- **Anthropometrical status: weight, height, waist-to-hip ratio, percentage fat**
- **Dietary intake**
- Level of activity
- Body image (perception and attitude)
- Biochemical parameters indicative of:

    Prevalence and risk of cardiovascular disease

    Prevalence and risk of type 2 diabetes

    Prevalence and risk of obesity (leptin status)

    Iron status

    HIV status

    Cancer risk

For the purpose of this study, the relationship between anthropometry, dietary intake and type 2 diabetes was determined.

Data was collected by a research team under leadership of the project manager. The researcher was involved in the following:

Design and adaptation of socio-demographic and food frequency questionnaires;

Collection of blood samples (assisting nursing sister);

Measurement of anthropometric variables;

Administering of FFQ.

4.2 PILOT STUDY

Ten African women in the age group 25-44 took part in the pilot study. The subjects comprised Technikon Free State personnel (Class C workers), and local domestic workers. During the pilot study, the following measuring instruments were standardised:

- A socio demographic questionnaire;
- Other questionnaires not applicable to this study;

The information collected during the pilot study, indicated the number of subjects who could be handled with ease during one data collection session, as well as the necessity of additional help of interpreters when administering the questionnaires.

The FFQ was pre-tested on a sample of thirty women in Mangaung. This pilot study also served as a reliability and validity study, and will be discussed under 4.6.1.

4.3 POPULATION AND SAMPLING

A sample of 500 African women, from the two age groups 25-34, and 35-44 years, were selected randomly in Mangaung, the African residential area of Bloemfontein, by the Department of Biostatistics, University of the Free State, using a township map obtained from the Greater Bloemfontein Municipality. The sample included respondents from two built-up areas, namely Pahameng and Botchabela, and two informal settlements, namely Joe Slovo and Namibia.

The residential plots in the four selected areas were counted and numbered, and a proportionate number of respondents were selected randomly from these plots. In Namibia 2995 plots were counted, 1711 in Pahameng, 1359 in Joe Slovo, and 2308 in Botchabela. The size of the sample was considered representative of the Mangaung population.

Twenty subjects were recruited per week to attend the research session at the Technikon Free State, conducted over a period of 25 weeks, commencing in March 2000, and ending in November 2000.

Inclusion / exclusion criteria:

- Persons took part in the research study voluntarily;
- African female;
- Within the age group 25-44;
- Non-pregnant;
- Fasting from 22:00 the night prior to data collection;
- Persons had to be available for the full duration of the investigation session (one day).

4.4 OPERATIONAL DEFINITIONS

For the purpose of this study, operational terms are defined as follows:

4.4.1 ANTHROPOMETRY

Anthropometry involves obtaining physical measurements of an individual, and relating these measurements to standards that reflect the health and nutrititonal status of the subject (Lee & Nieman, 1996, p. 224, Hammond, 2000, p. 368).

For the purpose of this study, the following anthropometric parameters were used:

- A waist-to-hip circumference ratio of ≥ 0.8 in the African women, indicative of an android fat distribution (Hammond, 2000, p. 372), and a waist-to-hip ratio of <0.8, indicative of a gynoid fat distribution.
- Weight and height measurements were obtained to determine BMI, as follows: W/H^2, in which W is weight in kilograms and H is height in meters squared, with:

  Underweight BMI: <18.5;

  Lower normal weight BMI: 18.5<20 ;

  Normal BMI: 20<25;

  Overweight BMI: 25<30;

  Obese BMI: ≥30 (Laquatra, 2000, p. 493).
- Waist circumference was categorised as follows:

  <0.88: Normal waist circumference;

  ≥0.88: High waist circumference (Smolin & Grosvenor, 2000, p. 213).
- Fat percentage was categorised as follows:

  <20: Low;

  20≤25: Normal;

  >25: High (Laquatra, 2000, p. 488).

Bioelectrical impedance analysis, a simple, quick and safe method, which compares well with skinfold measurements, was used in this study to determine fat percentage. This method which is based on the principal that, compared to fatty tissue, lean tissue has a higher electrical conductivity and lower impedance, relative to water, based on electrolyte content, was used to determine body composition (Bodystat R 1500 – Bodystat, Isle of Man, Limited; Hammond, 2000, p. 373; Lee & Nieman, 1996, p. 272; Pressman & Adams, 1990, p. 52). A fat percentage between twenty and 25 was considered normal (Laquatra, 2000, p. 488). Elbow width was determined using a sliding ruler to determine frame size, required to calculate fat percentage.

4.4.2 DIETARY INTAKE

Dietary intake was determined by means of a Quantitive Food Frequency Questionnaire. This method of dietary assessment was considered to be a good representation of the dietary intake of the large number of women who participated in this epidemiological study. The questionnaire was used to determine the habitual types and quantities of foods and drinks consumed by the respondents during the six months prior to data collection, and to determine the habitual intake of the following:

- Energy;
- Proteins;
- Carbohydrates;
- Fats;
- Vitamins: folic acid, niacin, riboflavin, thiamin, vitamin A, vitamin B12, vitamin B6, vitamin C, vitamin D, vitamin E, vitamin K;
- Minerals: Calcium, Iron, iodine, magnesium, phosphorus, selenium, zinc.

All nutrients were categorised as <67 percent or ≥67 percent of the recommended dietary intake (RDA) or adequate intake (AI)

4.4.3 BIOCHEMICAL PARAMETERS

Variables from the blood sample were categorised as follows:

- Triglycerides : <2; ≥2 mmol/l (Roche Diagnostics GmbH, Mannheim, Germany, catalogue no. 488872);
- Cholesterol ≤0,9; >0,9<5,2; 5,2<7,8; ≥7,8 mmol/l (Roche Diagnostics GmbH, Mannheim, Germany, catalogue no. 1489232);

- Albumin <34; 34-48; ≥48 g/l (Roche Diagnostics GmbH, Mannheim, Germany, catalogue no. 1970569);
- Glucose <3,05; 3,05-6,38; >6,38 mmol/l (Roche Diagnostics GmbH, Mannheim, Germany, catalogue no. 1448668)
- Insulin <2; 2-25; >25 μU/ml (DRG Diagnostics, catalogue no. EIA-2935).

For the purpose of this study, type 2 diabetes was defined as follows:

- A fasting blood glucose level higher than 6.38 mmol/l (ADA Physicians Guide to Non Insulin Dependent Diabetes);
- Hyperinsulinaemia was defined as a fasting insulin level of ≥25μU/ml was used as cut-off point for hyperinsulinaemia (Zilva et al., 1988, p. 445).

4.5 MATERIALS AND METHODS

The following materials and methods were used for the study:

4.5.1 SOCIO DEMOGRAPHIC STATUS

The socio-demographic composition of the subjects was determined by means of a questionnaire (Appendix A).

The questionnaire was administered by a B Tech Food Service Management student, and included the following demographic information:

- Identifiable details of the respondent (date of birth, residential address and telephone number and language);
- Number of years residing in a rural area;

- Number of children born and alive;
- Smoking habits;
- Household composition;
- Marital status;
- Highest level of education;
- Employment status of respondent, husband / partner;
- Head of the household;
- Type and size of dwelling;
- Facilities available (source of drinking water, type of toilet and fuel, cold storage and freezing facilities, type of stove(s), television and radio);
- Income (number of people contributing, average household income per month);
- Amount of money spent on food weekly.

4.5.2 ANTHROPOMETRY

Appendix B represents the anthropometric form that was used in the study. Anthropometric status of the subjects was determined by means of the following measurements:

- Weight:;
- Height;
- Circumferences (waist, hip);
- Bio-impedance.

Weight was determined with a "Seca" digital electronic scale, to the nearest 0,1 kilogram, with the subject dressed in an examination gown (Pressman & Adams, 1990, p. 46; Lee & Nieman, 1996, p. 229). The scale was placed on a flat, hard surface. The subject had to stand in the

- Number of children born and alive;
- Smoking habits;
- Household composition;
- Marital status;
- Highest level of education;
- Employment status of respondent, husband / partner;
- Head of the household;
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middle of the scale's platform, without touching anything, and with the body weight distributed on both feet. Weight was then read to the nearest 0,1 kg (Lee & Nieman, 1996, p. 228).

Height was determined by means of a stadiometer, to the nearest 0,5 centimeters. Measurements were taken with the subject dressed in an examination gown, standing barefoot on a flat surface, with heels together, arms to the side, legs straight, shoulders relaxed, and looking straight ahead (Pressman & Adams, 1990, p. 46; Lee & Nieman, 1996, p. 225). Heels, buttocks, scapulae and the back of the head were against the vertical board of the stadiometer. The headboard was then lowered upon the highest point of the head with enough pressure to compress the hair. The measurement was then read with the eye level with the headboard (Lee & Nieman, 1996, p. 225-226).

Waist and hip circumferences were determined with the subject dressed in light underwear and a gown, standing erect, abdominal muscles relaxed, arms at the side, and feet together. Both measurements were determined with a flexible tape measure to the nearest 0,5 cm, maintaining close contact with the skin, without compression of the underlying tissue. The waist was measured with the tape measure placed in a horizontal plane, at the minimal abdominal circumference located midway between the lower rib margin and the iliac crest. The hip was defined as the widest circumference over the great trochanters, and was measured with the tape measure in a horizontal plane around this area to the nearest 0,1 cm. The waist-to-hip ratio was calculated by dividing the waist circumference by the hip circumference (Lee & Nieman, 1996, p. 245).

Measurements of the participants were taken after an overnight fast, and after voiding. The same persons, namely a registered dietician, and a qualified anthropometrist, took all the measurements throughout the study. All measurements were taken once, with participants wearing a light examination gown, without shoes.

4.5.2.1 BODY MASS INDEX

- Body mass index was determined as W/H^2, in which W is weight in kilograms and H is height in meters squared.

4.5.2.2 FAT DISTRIBUTION

Fat distribution was determined by means of waist and hip circumference measurements. The ratio was calculated by dividing waist circumference by hip circumference.

4.5.2.3 FAT PERCENTAGE

Bioelectrical impedance analysis was used to determine body composition for fat (Bodystat R 1500 – Bodystat, Isle of Man, Limited). This technique is based on the principle that, compared to fatty tissue, lean tissue has a higher electrical conductivity and lower impedance, relative to water, based on electrolyte content (Hammond, 2000, p. 373; Lee & Nieman, 1996, p. 273). Respondents were instructed to follow the guidelines for consistent and accurate results, when written consent was obtained.

These guidelines included the following:

- No eating or drinking after 22:00 on the night prior to the procedures;
- No exercising within 24 hours of the test;
- No alcohol and caffeine consumption within 24 hours of the test.

The procedures were as follows:

- The bladder of the subject was emptied;
- Subjects were dressed in a light examination gown, without shoes and stockings / socks;

- Height and weight were determined accurately, as described elsewhere;
- Elbow width was measured with a sliding rule to establish whether the respondent had a Small, Medium or Large frame, which then defined which of the three Metropolitan Standard Weight Scales were appropriate.

- Elbow measurement was determined as follows:

  The respondent was instructed to stand and stretch out the right arm, palm up, so that the arm is horizontal to the ground.

  While bending at the elbow, the lower arm was brought up to the vertical position.

  The width between the protruding condiles of the elbow was measured, using the caliper.

  The reading was recorded (Bodystat R1500 Bodystat, Isle of Man, Limited).

- Subjects lay relaxed and flat on an examination bed, with the arms and legs slightly spread, but with no parts of the body touching one another.
- The self-adhesive disposable electrodes were attached to the right hand and the right foot.
- One red lead was placed behind the knuckle of the middle finger of the right hand.
- One black lead was placed on the wrist next to the ulna head of the right hand.
- The other red lead was placed behind the second toe next to the big toe of the right foot.
- The other black lead was placed on the ankle at the level of, and between the medial and lateral malleoli (the large protruding bones on the sides of the ankle) of the right foot.
- Electrodes supplied by Bodystat were used.
- The machine was switched on, and when the reading was stabilized, the impedance reading was recorded (Bodystat R1500 Bodystat, Isle of Man, Limited).

4.5.3 DIETARY INTAKE

To determine the habitual intake of nutrients by the participants, a standardised food frequency questionnaire (FFQ), adapted from the Transition and Health During Urbanisation of South Africans (THUSA) study (Potchefstroom University), was developed (Appendix C).

A FFQ was chosen to determine dietary intake due to the fact that FFQ's are the chosen method to use for describing intake of groups rather than for individuals (Dwyer, 1998, p. 945), and are commonly used in epidemiological research on diet and disease (Willett, 1990). Furthermore, it provides an overall picture of food intake (Dwyer, 1998, p. 943; Hammond, 2000, p. 369), which may be more representative of the usual intake of the individual than a few days of diet records. This method is also relatively inexpensive for large sample sizes. The design can be based on large-population data, and it is a suitable method to choose for research on diet-disease relationships (Lee & Nieman, 1996, p. 107; Dwyer, 1998, p. 943).

The FFQ comprised food items that are habitually consumed by the participants. Both traditionally consumed, and Western foods were included. Provision was made for the addition of unlisted food items.

Additional sections added to the FFQ included the following:

- Following of any special diet;
- Use of salt and flavoured salts;
- Use of commercial stock cubes in cooking;
- Use of dietary supplements;
- Eating pattern usually followed;
- Inclusion of breakfast in the day's meals;
- Regularity of food consumed away from home;
- Regularity of coffee and tea consumption;
- Inclusion of meat, fish and poultry in the daily meal pattern;
- Consumption of fresh fruit and vegetables during meals.

A special section for reporting foods hunted or collected, such as wild birds, animals, insects, fruit and berries were included in the questionnaire.

FFQ were administered by the researcher, two dieticians, and one B Tech Food Service Management student, after attending a training session by a dietician who participated in the National Food Consumption Survey.

Three interpreters (one Xhosa and two Sotho speaking) assisted the interviewers. Prior to each interviewing session, the procedures for reporting dietary intake were explained to the respondent.

Participants were requested to report food items selected from the different categories listed in the FFQ, as consumed daily, weekly, monthly or seldom.

The following materials and equipment were used to determine food choices and portion sizes:

A set of household measuring cups (250 ml, 125 ml, 62 ml and 31 ml);

A set of household measuring spoons (15 ml, 7,5 ml, 5 ml, 2,5 ml, 1,2 ml and 0,6 ml);

A large household spoon used for dishing up (heaped spoon, 125 ml);

Empty labeled food containers;

Real food (snack foods), weighed on an analytical scale to determine the weight for commonly used portion sizes;

Food models.

The recorded food items were coded by means of the Food Composition Tables of the Medical Research Council (Langenhoven et al., 1998). The quantities of food items recorded on the questionnaire were converted to gram weights using the Food Quantities Manual (Langenhoven et al., 1991). The data was summarized on a coded summary sheet before it was processed.

The weight of food items consumed on a daily basis was entered as such. The weight of food items not selected by the respondents on a daily basis, was calculated as follows:

- Food in grams consumed on a monthly basis ÷ 30 days;
- Food in grams consumed on a weekly basis ÷ 7 days.

Complex dishes not appearing in the Food Composition Tables, were broken down into individual ingredients and weights, and coded as such.

4.5.4 BLOOD SAMPLING

Blood samples of the subjects were collected after an overnight fast. The following materials and methods were used:

A qualified nursing sister collected the blood samples. The respondents were sitting in a relaxed and comfortable position, either on a chair or a laboratory stool.
Blood samples were collected from the cubital fossa vein, using "Vacutainer Systems" needles, 21 G. (thickness) X 38 mm (length) and a tourniquet. Preptic swabs were used to disinfect the area before blood was drawn.

10 ml Vacutainer (BD, TM; catalogue number 368430, Plymouth, UK.) blood tubes (red stopper), were used for blood samples for total protein, albumin, serum insulin and plasma glucose. 10 ml Vacutainer EDTA blood tubes (purple stopper) were used for full blood samples.

4.5.4.1 BIOCHEMICAL ANALYSIS

Blood samples were used to determine fasting triglycerides, fasting total cholesterol, fasting serum albumin, fasting serum glucose and fasting serum insulin levels of the subjects.

i) BLOOD SAMPLES

10 ml of whole blood was left to clot at room temperature. These samples were centrifuged at 3360 rpm for 20 minutes in order for serum to separate. Serum samples were frozen at –72°C in Eppendorf^{R} vials for later analyses.

ii) FASTING TRIGLYCERIDES

Fasting triglycerides were determined using the GPO-PAP method supplied by Roche Diagnostics GmbH, Mannheim, Germany (catalogue no. 148872). The method is based on an enzymatic colorimetric principle. This method is based on the work by Wahlefeld using a lipoprotein lipase from micro-organisms for the rapid and complete hydrolysis of triglycerides to glycerol followed by oxidation to dihydroxyacetone phosphate and hydrogen peroxide. The hydrogen peroxide produced then reacts with 4-aminophenazone and 4-chlorophenol under the catalytic action of peroxidase to form a red dyestuff (Trinder endpoint reaction). The Coefficient of variation (CV) for this method was 1.29 percent.

iii) TOTAL CHOLESTEROL

Total cholesterol was determined using the CHOD-PAP method (catalogue no. 1489232) supplied by Roche Diagnostics GmbH, Mannheim, Germany. This method is based on an enzymatic colorimetric principle. This method is based on the determination of Δ^4–cholestenone after enzymatic cleavage of the cholesterol ester by cholesterol esterase, conversion of cholesterol by cholesterol oxidase, and subsequent measurement by the Trinder reaction of the hydrogen peroxide formed. Optimization of ester cleavage (>99.5 %) allows standardisation using primary and secondary standards and a direct comparison with the CDC and NIST reference methods. The CV for this method was 0.33 percent.

iv) SERUM ALBUMIN

Serum albumin was determined using a colorimetric endpoint method supplied by Roche Diagnostics GmbH, Mannheim, Germany (catalogue no. 1970569), on the Boehringer Mannheim/ Hitachi 902 automatic chemistry analyzer. At a pH value of 4.1, albumin displays a sufficiently cationic character to be able to bind with bromcresol green (BCG), an anionic dyestuff, to form a blue-green complex. The colour intensity of the blue-green colour is directly proportional to the albumin concentrate, and can be determined photometrically. The method was calibrated against Calibrator for Automated Systems supplied by Roche Diagnostics GmbH, Mannheim, Germany (catalogue no. 759350). Precinorm U, for normal values (Roche Diagnostics GmbH, Mannheim, Germany, catalogue no. 171735), and Precipath U (Roche Diagnostics GmbH, Mannheim, Germany, catalogue no. 171778) for pathological range values (Roche Diagnostics GmbH, Mannheim, Germany, catalogue no. 171778) were used as control samples for reliability of the measurements. The CV for the method was 2.05 percent.

v) SERUM GLUCOSE

Glucose was determined using an enzymatic colorimetric method, supplied by Roche Diagnostics GmbH, Mannheim, Germany (catalogue no. 1448668) on a Boehringer Mannheim Hitachi 902 automatic chemistry analyzer.

Glucose was oxidized by glucose-oxidase (GOD), in the presence of atmospheric oxygen to gluconolactone oxidiert. The resulting hydrogen peroxide was oxidized in the presence of peroxidase (POD) 4-amino-phenazone and phenol to 4-(p-benzochinonemonolmino)-phenazone. The colour intensity of the red dye is directly proportional to the glucose concentration and was determined photometrically. The method was calibrated against

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vi) SERUM INSULIN

The DRG insulin ELISA is a solid phase two-site enzyme immunoassay. It is based on the direct sandwich technique in which two monoclonal antibodies are directed against separate antigenic determinants on the insulin molecule. During incubation, insulin in the sample reacts with biotin-conjugated anti-insulin antibodies, and anti-insulin antibodies bound to microtitration well. A simple washing step removes unbound biotin labeled antibody. During the second incubation step, Streptavidin Peroxidase Enzyme Complex binds to the biotin-anti-insulin antibody. The bound HRP complex is detected by reaction with 3,3', 5,5'-tetramethylbenzidine. The reaction is stopped by adding acid to give a colorimetric endpoint that is read spectrophotometrically. The CV for the method was 6.8 percent.

4.6 RELIABILITY AND VALIDITY

Reliability and validity of anthropometry, dietary intake and biochemical analysis will be discussed.

4.6.1 ANTHROPOMETRY

In order to ensure validity and reliability of results, anthropometric measurements were obtained by a qualified anthropometrist, according to standard procedures, as recommended by Lee & Niemann, and Bodystat (Lee & Niemann, 1996, 225, 228-229, 244-245; Bodystat R1500 Bodystat, Isle of Man, Limited).

4.6.2 DIETARY INTAKE

Both reliability and validity are important factors to consider when records of the individual's food intake are obtained.

Before commencing with the research study, the FFQ was tested for reliability and validity. A sample of 30 African women living in the Mangaung area, was recruited for this purpose by two Community Health Workers, the week before the study. During this first contact session, the Community Health Worker explained the purpose of the study to the subjects. These subjects were selected independent from the main study.

Five researchers taking part in the main project, visited the selected area, where respondents were interviewed at a central point. Subjects were interviewed individually to determine their habitual intake of food, by means of the FFQ. The same procedures followed for the main study, were used.

After the interview, each subject was issued with a domestic scale calibrated in grams, a note

book, a set of household measuring cups and spoons, and a pencil. Subjects were then clearly instructed on how to weigh and record their food intake for a period of 7 days. The need for accuracy in weighing and recording food intake was emphasised.

To test the consistency of the data obtained during the first administering of the FFQ, the procedure was repeated with the same subjects, after 1 month. Dietary records and measuring equipment were collected, and the FFQ was re-administered.

Information obtained during the first and second FFQ interviewing sessions was compared to determine reliability. Information obtained during the first FFQ interviewing session was also compared with the 7-day weighed record, in order to determine validity of food intake data.

4.6.3 BIOCHEMICAL ANALYSIS

Coefficient of variation has been calculated by means of the following equation, using the values obtained from controls, respectively: $\frac{\bar{x}}{sd} \times \frac{100}{1}$

4.7 STATISTICAL ANALYSIS

The data for all data sets were categorised into age groups: 25-34 years, and 35-44 years. For each group, continuous variables were described by means and standard deviations, or medians and percentiles as applicable. Categorical variables were described by frequencies and percentages.

4.7.1 ANTHROPOMETRY

Body mass index (weight / height m^2), waist-hip-ratio (waist / hip), waist circumference and fat percentage were calculated and categorised according to the cut-off points discussed under 4.4.1 under Operational definitions. For each age group, the categorised variables were described by frequencies and percentages.

4.7.2 DIETARY INTAKE

The nutrient intake of each respondent was calculated using the Food Composition Tables of the MRC (1998), and described for each group by medians and percentiles because the data were skewly distributed. All nutrients were categorised as <67 percent or ≥67 percent of the recommended dietary intake (RDA) or adequate intake (AI) and described by frequencies and percentages.

4.7.2.1 RELIABILITY OF FFQ

The difference in nutrient intake for each respondent between the two FFQ surveys was calculated and presented as a percentage of the mean of the two. The reliability of nutrients where the calculated mean percentage differed more than ten percent, were classified as uncertain (Wheeler et al., 1994).

EXAMPLE:

Difference=(intake 2 – intake 1) / (intake 2 + intake 1) / 2) x 100.

95 Percent confidence intervals for the mean percentage of a single sample were calculated (Gardner & Altman, 1989, p. 20) to determine if mean percentage differences were statistically significant.

4.7.2.2 VALIDITY OF FFQ

The difference in nutrient intake for each respondent between the two surveys (FFQ and weighed records) was calculated and presented as a percentage of the mean of the two. The validity of nutrients where the calculated mean percentage differed more than ten percent, were classified as uncertain (Wheeler et al., 1994).

EXAMPLE:

Difference= (intake 2 – intake 1) / (intake 2 + intake 1) / 2) x 100.

95 Percent confidence intervals for the mean percentage of a single sample were calculated (Gardner & Altman, 1989, p. 20) to determine if mean percentage differences were statistically significant.

4.7.3 BIOCHEMICAL ANALYSIS

Variables from the blood sample were categorised according to the cut-off points discussed under 4.4.1 under Operational definitions. For each age group, the categorised variables were described by frequencies and percentages.

4.7.4 ASSOCIATIONS

To determine whether waist circumference is associated with glucose level, a 2 x 2 table of categorised waist circumference and categorised glucose level was constructed, and the risk of high blood glucose level in the waist circumference categories was compared by a Jeffreys-Perks CI for the difference between independent percentages (Newcombe, 1998).

To determine whether BMI and triglyceride levels are associated, a 4 x 2 table of categorised BMI and categorised triglyceride levels was constructed and the risk of high triglyceride level in the BMI categories was compared by a Jeffreys-Perks CI for the difference between independent percentages (Newcombe, 1998).

Insulin sensitivity (10000 / (glucose x insulin)) was calculated and categorised into quartiles.

The medians of body mass index, waist-hip-ratio, and triglyceride levels were compared between all insulin sensitivity quartiles by 95 percent non-parametric CI for the median difference (Donahue et al., 1988). The CI were clinically interpreted for significance.

4.8 STUDY PROCEDURES

Prior to the study, approval of the research project by the Community leaders of the four selected areas, namely, Pahameng, Botschabela, Joe Slovo and Namibia, was obtained. A letter explaining the extent and purpose of the study was written to these Community leaders (Appendix D). A talk by the study leader on Radio Lesedi, served as a further method to inform the local community of Mangaung about the study. In addition, two community health workers who supported the researchers, addressed community meetings in each of the four areas to explain the purpose and procedures of the study.

Twenty subjects from the selected areas were visited by the community health workers at their residences the week before they attended the research session at Technikon Free State. If a selected respondent was not available, the community health worker moved to the residence situated to the right of the selected residence. If not successful, the community health worker visited the residence situated to the left of the first selected residence. If this failed, a new plot was selected by the Department of Biostatistics, UFS. During these contact sessions, the

community health workers explained the details of the research study. Respondents took part in the study voluntarily. The subjects gave written informed consent (Appendix E), approved by the Ethical Committee of the Faculty for Health Sciences, UFS, after the purpose and procedures of the study were thoroughly explained by the community health worker. Employed respondents were issued with a letter which explained the purpose of the study to employers (Appendix F). Respondents were instructed to fast overnight, abstain from exercising for 24 hours, and avoid consuming alcohol and caffeine for 24 hours prior to the collection of data. The subjects were informed to gather at a central point for collection at 08:00 on the day of data collection, after which they were transported by mini buses to the research centre, where all investigations took place. Each respondent received a remuneration of R40,00 for taking part in the research study. The community health workers were also remunerated for their contribution.

On the morning of arrival at the research centre, each respondent was issued with a name tag including a list of the seven stations that each respondent had to move through. The specific station was marked off as the respondent had moved through it. Three interpreters were available to assist the researchers at the stations where language problems were encountered. A research assistant coordinated the procedures to ensure that each respondent visited each of the stations.

The stations were the following:

- General examination by a medical practitioner;
- Station where blood samples were collected;
- Station where weight, height, circumferences and Bio-impedance were determined;
- Station where FFQ was administered;
- Station where socio-demographic data was collected;
- Other stations not applicable to this study.

After the subjects had undergone the medical examination, measurements had been taken and blood samples had been collected, tea and sandwiches were served.

After all the procedures had been completed, the respondents received their remuneration. Subjects were responsible for their own transport back to their residential areas.

4.9 SUMMARY

The effect of the nutrition transition, including the increase in the prevalence of chronic diseases of lifestyle, such as type 2 diabetes mellitus, has prompted the need to determine the association between anthropometry, dietary intake and type 2 diabetes mellitus.

A sample of 500 healthy, pre-menopausal African women, from the two age groups 25-34, and 35-44 years, considered to be representative of the Mangaung area of Bloemfontein, was randomly selected for the study, by using a township map.

The socio-demographic composition of the subjects was determined by means of a questionnaire, which included identifiable details of each subject, the family composition, household and economic status.

Blood samples were collected, by using standard procedures, to determine the triglyceride, total cholesterol, serum albumin, serum glucose, and serum insulin status of each subject.

Weight, height, circumference (waist and hip), and bioimpedance measurements were obtained, and used to calculate BMI, fat percentage and fat distribution of each respondent.

Dietary intake of respondents was determined by means of a standardised FFQ, including traditional and Western foods, after which they were analysed to determine the habitual intake of respondents.

CHAPTER 5

RESULTS

5.1 INTRODUCTION

The mean age of the women from the younger group who participated in this study, was 29.2 years, and from the older group 39.5 years. From the women of the younger group, 52.3% was Sotho speaking and 25.1% Tswana speaking. From the older women 51.1% was Sotho speaking, and 26.7% Tswana speaking. In the younger group, the mean number of years living in an urban area was fifteen years, while in the older group it was nineteen years. Room density was high in both groups (mean 3.2 persons/room and 3.1 persons/room for the young and old age groups respectively). Results from the question on the level of education showed that the highest level of education appeared in women from the younger group on secondary school level (standard 6-8: 37.6%, and standard 9-10: 47.3%). In the older group, the highest level of education appeared in the standard 6-8 category (42.4%), while 15.7% had standard 9-10. The employment status showed that the largest percentage of women from both age groups, was unemployed (74.6% and 67.7% in the younger and older groups respectively).

The results of the study are presented under the following headings: anthropometry, dietary intake, biochemical parameters and associations. Results of the validity and reliability study of dietary intake by means of the food frequency questionnaire will also be given.

5.2 ANTHROPOMETRY

Results of BMI, WHR and fat percentage follow.

5.2.1 BODY MASS INDEX

The BMI of women in both age groups is indicated in Table 5.1. More than half of the women in both age groups demonstrated a BMI above normal (overweight and obese). In the younger age group, 30.1% of the women fell in the overweight category, while in the older age group, 27.7% of the women were overweight. Twenty three percent from the younger women, and 24 percent from the older women had a BMI $\geq$ 30, indicating obesity (Laquatra, 2000, p. 493). A larger percentage of women from the younger age group had a normal BMI.

Table 5.1: Body mass index of women

	Body mass index categories									
Age group	**<18.5 Underweight**		**18.5<20 Lower normal weight**		**20<25 Normal weight**		**25<30 Overweight**		**≥30 Obese**	
25-34 Years	N	%	N	%	N	%	N	%	N	%
(n = 279)	7	2.5	14	5.0	109	39.1	84	30.1	65	23.3
35-44 years (n = 217)	9	4.1	17	7.8	79	36.4	60	27.7	52	24

5.2.2 WHR (FAT DISTRIBUTION)

The WHRs for women of the two age groups are presented in Table 5.2. Most women in both age groups had a WHR smaller than 0.8, indicating a peripheral fat distribution (Hammond, 2000, p. 372). The mean WHR for the younger group was 0.74, and for the older group 0.78. In the younger group, 83.5% of the women had a WHR smaller than 0.8, and in the older group 62.7%. Of particular interest is the difference (20.8%) in the percentage of women with a peripheral fat distribution between the two age groups.

Table 5.2: WHR of women

	WHR			
	<0.8		≥0.8	
Age group	**N**	**%**	**N**	**%**
25-34 years (n = 279)	233	83.5	46	16.5
35-44 years (n = 217)	136	62.7	81	37.3

5.2.3 FAT PERCENTAGE (BODY COMPOSITION)

Table 5.3 presents the fat percentage for the respondents of both age groups.

Table 5.3: Fat percentage of women

	Low <20%		Normal 20≤25%		High >25%	
Age group	**N**	**%**	**N**	**%**	**N**	**%**
25-34 years (n = 279)	3	1.1	18	6.5	258	92.5
35-44 years (n = 217)	3	1.4	10	4.6	204	94

Almost all subjects had a fat percentage higher than the recommended (normal) 20-25% (Laquatra, 2000, p. 488). The majority of subjects from both age groups demonstrated high fat percentages (92.5% and 94% respectively). Only 6.5% of the younger women, and 4.6% of the older women respectively showed normal fat percentages. The mean fat percentage in the young women was 36.6 percent, while in the older women, the mean fat percentage was 38.5 percent.

5.3 DIETARY INTAKE

Median values of intakes are indicated in tables, because data was not equally distributed. Mean intakes have also been included, to make comparison with other studies that used mean intakes possible.

Results of the validity and reliability study of the FFQ are indicated in Tables 5.4 to 5.11. Results of mean nutrient intakes obtained in the main study are presented in Tables 5.12 to 5.21, and results of the thirty most frequently consumed foods by mass, in Tables 5.22 and 5.23.

5.3.1 VALIDITY AND RELIABILITY OF FFQ

Prior to the main study, the FFQ was administered to a sample of 30 women. Three weeks later the FFQ was re-administered to the same sample in order to determine the reliability of the questionnaire. They also kept a weighed record (WR) of all foods and drinks consumed for a period of one week to determine the validity of the questionnaire. For both the reliability and validity studies, the difference in nutrient intake for each respondent between the two surveys was calculated and presented as a percentage of the mean of the two. The reliability of nutrients where the calculated mean percentage differed more than 10% was considered uncertain. Ninety five percent CI for the mean percentage of a single sample were calculated (Gardner and Altman, 1989, p. 20) to determine if mean percentage differences were statistically significant.

5.3.1.1 RELIABILITY

The FFQ's of 30 women were completed in an interview as part of the first survey. Only 21 women were available to complete the second FFQ.

i) ENERGY, MACRONUTRIENTS AND CHOLESTEROL

Mean percentage differences and 95% CI for mean percentage differences for energy, macronutrient and cholesterol intake of the two FFQ interviews are indicated in Table 5.4.

Table 5.4: Energy, macronutrient and cholesterol intake (N=21)

Nutrient		Mean	SD	Mean % difference	95% CI for mean difference
Energy (kJ)	FFQ1	11790.71	4154.07	8.23	-14.33; 30.78
	FFQ2	13757.88	7573.90		
Total protein (g)	FFQ1	89.20	33.19	6.31	-19.03; 31.66
	FFQ2	98.28	44.08		
Plant protein (g)	FFQ1	45.57	17.94	2.78	-20.27; 25.82
	FFQ2	49.54	28.01		
Animal protein (g)	FFQ1	41.9	20.06	6.46	-27.26; 40.18
	FFQ2	45.46	19.96		
Total Carbohydrates (g)	FFQ1	391.83	141.26	3.64	-15.86; 23.15
	FFQ2	425.54	219.20		
Total dietary fibre (g)	FFQ1	29.51	16.15	-1.14	-28.51; 26.23

Table 5.4: Energy, macronutrient and cholesterol intake (N=21) (Continued)

Nutrient		Mean	SD	Mean % difference	95% CI for mean difference
Saturated fat (g)	FFQ1	22.59	10.47	17.35	-15.59; 50.30
	FFQ2	29.28	16.84		
PUFA (g)	FFQ1	22.54	14.60	25.31	-10.39; 61.01
	FFQ2	38.85	49.93		
MUFA (g)	FFQ1	26.85	15.52	17.33	-14.67; 49.34
	FFQ2	35.83	24.39		
Cholesterol (mg)	FFQ1	326.47	239.48	-1.67	-38.87; 35.53
	FFQ2	305.11	179.25		

The mean percentage difference in the intake of energy, total protein, plant protein, animal protein, total carbohydrate, total dietary fibre and cholesterol differed with less than 10% in the two FFQ interviews and reliability of these nutrient intakes was thus considered to be good. Mean percentage differences for fat intake (total fat, saturated fat, Poly-unsaturated fats (PUFA) and mono-unsaturated fats (MUFA) differed with more than 10% and their reliability was thus considered uncertain (ranging from 17.35% for saturated fat to 25.31% for PUFA). However, 95% CI for the mean percentage differences indicated that differences were not statistically significant.

ii) MINERALS AND TRACE ELEMENTS

Mean percentage differences between the mineral and trace element intakes for the two FFQ interviews are indicated in Table 5.5.

Table 5.5: Mineral and trace element intake (N=21)

Nutrient		Mean	SD	Mean % difference	95% CI for mean % difference
Calcium (mg)	FFQ1	578.52	313.27	22.23	-11.07; 55.67
	FFQ2	833.29	623.98		
Chromium (µg)	FFQ1	53.49	40.72	8.68	-31.76; 49.13
	FFQ2	52.74	41.81		
Copper (mg)	FFQ1	2.24	1.43	-9.51	-42.02; 22.99
	FFQ2	2.01	1.30		
Iron Haem (mg)	FFQ1	0.90	1.34	-0.48	-55.26; 54.31
	FFQ2	0.72	0.81		
Iron non-haem (mg)	FFQ1	5.07	3.70	-6.16	-41.46; 29.15
	FFQ2	4.19	2.44		
Total iron (mg)	FFQ1	15.57	8.58	2.50	-30.72; 35.71
	FFQ2	19.92	26.75		
Iodine (µg)	FFQ1	39.00	28.20	8.01	-24.10; 40.11
	FFQ2	37.72	19.65		
Potassium (mg)	FFQ1	3187.75	1737.45	3.13	-21.77; 28.04
	FFQ2	3252.23	1470.38		
Magnesium (mg)	FFQ1	442.97	160.39	2.73	-18.36; 23.82
	FFQ2	474.63	219.38		

Table 5.5: Mineral and trace element intake (N=21) (Continued)

Nutrient		Mean	SD	Mean % difference	95% CI for mea % difference
Manganese (µg)	FFQ1	3865.38	1735.88	0.19	-26.68; 27.06
	FFQ2	4162.84	2520.64		
Sodium (mg)	FFQ1	2097.17	1289.33	10.90	-22.37; 44.17
	FFQ2	2331.22	1384.30		
Phosphorus (mg)	FFQ1	1392.60	518.23	8.72	-14.67; 32.11
	FFQ2	1589.75	713.24		
Selenium (µg)	FFQ1	39.10	26.63	12.32	-21.61; 46.25
	FFQ2	41.77	30.69		
Zinc (mg)	FFQ1	11.50	4.54	3.02	-22.32; 28.36
	FFQ2	12.43	6.14		

Reliability of most minerals and trace elements was good. Mean percentage differences exceeded 10% for calcium (22.23%), sodium (10.90%) and selenium (12.32%). The 95% CI for mean percentage differences indicated that differences were not statistically significant.

iii) VITAMINS

Table 5.6 and Table 5.7 indicate the results of the reliability study for fat-soluble vitamins and water-soluble vitamins respectively.

Table 5.6: Fat-soluble vitamin intake (N=21)

Nutrient		Mean	SD	Mean % difference	95% CI for mea % difference
Vitamin A Re (µg)	FFQ1	1330.06	1351.86	-20.44	-66.02; 25.15
	FFQ2	848.23	658.94		
Vitamin D (µg)	FFQ1	3.53	2.51	32.58	7.49; 57.67
	FFQ2	4.54	2.52		
Vitamin E (mg)	FFQ1	14.82	9.13	15.63	-24.54; 55.80
	FFQ2	24.75	40.30		
Vitamin K (µg)	FFQ1	283.30	310.46	-13.64	-50.09; 22.82
	FFQ2	231.65	190.42		

As found with fat intake, mean percentage differences between vitamin intake of the two FFQ interviews for all fat-soluble vitamins were higher than 10% (ranging from –13,64% for vitamin K to 32.58% for vitamin D). The 95% CI for mean percentage difference of vitamin D was statistically significant.

Table 5.7: Water-soluble vitamin intake (N=21)

Nutrient		Mean	SD	Mean % difference	95% CI for mea % difference
Thiamin (mg)	FFQ1	1.67	0.79	8.63	-18.76; 36.03
	FFQ2	1.85	0.90		
Riboflavine (mg)	FFQ1	1.74	1.06	27.05	-10.38; 64.48
	FFQ2	2.61	1.82		
Niacin (mg)	FFQ1	20.45	10.92	6.68	-24.28; 37.63
	FFQ2	21.33	10.50		
Vitamin B6 (mg)	FFQ1	1.46	0.66	4.66	-22.83; 32.15
	FFQ2	1.59	0.85		
Folate (µg)	FFQ1	275.09	148.64	10.78	-16.11; 37.66
	FFQ2	307.85	161.93		
Vitamin B12 (µg)	FFQ1	10.98	17.70	3.85	-39.14; 46.85
	FFQ2	7.94	8.51		
Vitamin C (mg)	FFQ1	81.59	72.84	-20.41	-55.19; 14.38
	FFQ2	55.99	35.12		
Pantothenic acid (mg)	FFQ1	5.87	2.66	3.14	-23.99; 30.27
	FFQ2	6.22	2.78		
Biotin (µg)	FFQ1	60.12	54.42	-16.46	-49.40; 16.47
	FFQ2	42.68	22.05		

Mean percentage differences of less than 10% indicated that reliability of intakes for thiamin, niacin, vitamin B6, vitamin B12 and pantothenic acid was good. The mean percentage differences exceeded 10% for riboflavine (27.05%), folate (10.78%), vitamin C (-20.41%) and biotin (-16.46%). The 95% CI for the mean percentage differences

indicated that none of the differences were statistically significant. The CI for riboflavine, vitamin C, and biotin are very wide and must be interpreted with caution.

5.3.1.2. VALIDITY

The FFQ's of 30 women were completed in an interview as part of the first survey. Only 28 of these women completed the WR. Nutrient intakes obtained from the first FFQ and the WR were compared to determine validity of the FFQ.

i) ENERGY, MACRONUTRIENTS AND CHOLESTEROL

Mean percentage differences and 95% CI for mean percentage differences for energy, macronutrient and cholesterol intake of the FFQ and the WR are indicated in Table 5.8.

Table 5.8: Energy, macronutrient and cholesterol intake (N=28)

Nutrient		Mean	SD	Mean % difference	95% CI for mea % difference
Energy (kJ)	FFQ1	12591.82	5296.37	-26.07	-41.55; -10.59
	WR	9718.66	4123.97		
Total protein (g)	FFQ1	93.51	39.68	-21.32	-36.78; -5.86
	WR	74.11	28.32		
Plant protein (g)	FFQ1	47.56	22.25	-24.65	-42.27; -7.03
	WR	36.96	18.04		
Animal protein (g)	FFQ1	44.43	22.12	-24.16	-50.17;1.86
	WR	35.99	19.92		

Table 5.8: Energy, macronutrient and cholesterol intake (N=28) (Continued)

Nutrient		Mean	SD	Mean % difference	95% CI for mean difference
Total Carbohydrates (g)	FFQ1	414.77	163.58	-22.92	-40.35; -5.49
	WR	333.76	147.20		
Total dietary fibre (g)	FFQ1	29.44	15.79	-29.11	-47.65; -10.57
	WR	21.05	10.82		
Total fat (g)	FFQ1	90.84	58.01	-34.82	-53.82; -15.81
	WR	62.15	35.17		
Saturated fat (g)	FFQ1	25.00	14.05	-31.07	-52.93; -9.21
	WR	18.44	10.65		
PUFA (g)	FFQ1	25.36	18.46	-42.13	-64.07; -20.20
	WR	15.83	10.55		
MUFA (g)	FFQ1	30.87	22.11	-31.50	-50.84; -12.15
	WR	21.73	13.82		
Cholesterol (mg)	FFQ1	334.43	233.69	-44.76	-74.09; -15.43
	WR	186.57	96.28		

WR consistently gave intakes lower than those reported by the FFQ. For energy, all macronutrients and cholesterol the mean percentage difference between the FFQ and the WR was greater than 10% (ranging from –21.32% for total protein to –44.76% for cholesterol). The 95% CI for the mean percentage differences indicated that differences were all significant.

ii) MINERALS AND TRACE ELEMENTS

The mean percentage differences for minerals and trace elements are given in Table 5.9

Table 5.9: Mineral and trace element intake (N=28)

Nutrient		Mean	SD	Mean % difference	95% CI for mea % difference
Calcium (mg)	FFQ1	621.34	360.72	-26.06	-53.49; 1.38
	WR	537.52	449.42		
Chromium (µg)	FFQ1	56.62	43.84	-27.38	-53.10; -1.65
	WR	36.62	21.87		
Copper (mg)	FFQ1	2.20	1.38	-49.66	-72.27; -27.04
	WR	1.17	0.59		
Iron Haem (mg)	FFQ1	0.82	1.19	-29.36	-80.99; 22.28
	WR	0.50	0.45		
Iron non-haem (mg)	FFQ1	5.13	3.54	-32.88	-56.83; -8.93
	WR	3.17	1.32		
Total iron (mg)	FFQ1	15.66	8.53	-45.58	-66.29; -24.87
	WR	9.11	4.91		
Iodine (µg)	FFQ1	40.84	32.57	-27.45	-52.36; -2.54
	WR	26.53	13.79		
Potassium (mg)	FFQ1	3311.52	1822.24	-23.87	-41.53; -6.21
	WR	2442.83	946.22		
Magnesium (mg)	FFQ1	466.50	206.33	-17.96	-34.71; -1.21
	WR	384.24	155.84		
Manganese (µg)	FFQ1	3890.05	1698.95	-29.94	-48.96; -10.93

Table 5.9: Mineral and trace element intake (N=28) (Continued)

Nutrient		Mean	SD	Mean % difference	95% CI for mea % difference
	WR	2987.66	2087.07		
Sodium (mg)	FFQ1	2245.62	1328.44	-50.55	-74.27; -26.82
	WR	1400.48	1235.36		
Phosphorus (mg)	FFQ1	1465.63	621.71	-17.64	-33.28; -2.01
	WR	1221.16	495.38		
Selenium (µg)	FFQ1	39.30	29.70	-34.57	-57.74; -11.40
	WR	24.65	16.13		
Zinc (mg)	FFQ1	11.92	5.21	-19.04	-34.48; -3.61
	WR	9.53	3.49		

As with the macro-nutrients, the mean intakes of subjects obtained by the WR were lower than those obtained with the FFQ. For all minerals and trace elements, the mean percentage difference exceeded 10%.

iii) VITAMINS

Mean percentage differences and 95% CI for mean percentage differences for fat-soluble and water-soluble vitamins of the FFQ and the WR are indicated in Table 5.10 and Table 5.11 respectively.

Table 5.10: Fat-soluble vitamin intake (N=28)

Nutrient		Mean	SD	Mean % difference	95% CI for mea % difference
Vitamin A Re (µg)	FFQ1	1268.99	1214.30	-44.70	-75.59; -13.81
	WR	679.27	543.17		
Vitamin D (µg)	FFQ1	4.21	4.07	-44.51	-68.92; -20.10
	WR	2.40	1.98		
Vitamin E (mg)	FFQ1	15.37	9.77	-56.44	-80.30; -32.59
	WR	7.70	4.85		
Vitamin K (µg)	FFQ1	304.55	285.38	-30.48	-69.72; 8.75
	WR	252.45	248.96		

Mean intakes obtained for fat-soluble vitamins by the FFQ and WR were significantly different, indicating that the results obtained by the two methods were not comparable.

As found with all the other nutrients, mean intakes obtained for water-soluble vitamins by the two methods were significantly different.

Table 5.11: Water-soluble vitamin intake (N=28)

Nutrient		Mean	SD	Mean % difference	95% CI for mea % difference
Thiamin (mg)	FFQ1	1.72	0.83	-22.72	-39.75; -5.69
	WR	1.33	0.56		
Riboflavine (mg)	FFQ1	1.92	1.21	-47.67	-71.72; -23.62
	WR	1.08	0.62		
Niacin (mg)	FFQ1	20.66	11.49	-28.88	-53.28; -4.48
	WR	14.92	9.20		
Vitamin B6 (mg)	FFQ1	1.52	0.68	-28.03	-43.94; -12.12
	WR	1.12	0.57		
Folate (µg)	FFQ1	276.42	162.36	-33.46	-51.78; -15.15
	WR	192.61	121.53		
Vitamin B12 (µg)	FFQ1	9.80	15.46	-48.87	-82.73; -15.01
	WR	3.76	3.56		
Vitamin C (mg)	FFQ1	80.77	65.89	-45.65	-69.25; -22.05
	WR	40.92	19.44		
Pantothenic acid (mg)	FFQ1	5.96	2.83	-12.58	-35.62; 10.47
	WR	5.44	3.19		
Biotin (µg)	FFQ1	57.98	48.50	-34.04	-54.98;-13.09
	WR	34.02	13.88		

5.3.2 NUTRIENT INTAKE: MAIN STUDY

Results of nutrient intakes of the subjects as obtained in the main study, are presented in Tables 5.12 to 5.21.

5.3.2.1 ENERGY, MACRONUTRIENTS AND CHOLESTEROL

Tables 5.12 and 5.13 indicate the intake of energy, macronutrients and cholesterol of the two age groups.

The median energy intake of women in both age groups was markedly higher than the RDA of 9196 kilojoules (Johnson, 2000; p. 29). Maximum intakes of energy were also extremely high for both age groups, while only 11.5% of the younger group, and 12% of the older group of women showed intakes less than 67% of the RDA.

The median total protein intakes were above the RDA of 50 g/day (Earl, 2000; p. 334) for women of both age groups. Only 4.3% of women from the younger group, and 6% from the older group took in less than 67% of the RDA.

Tables 5.12 and 5.13 indicate the total fat intake, saturated fat intake, poly-unsaturated fat intake and mono-unsaturated fat intake of women of the two age groups respectively. For total fat intake, the median figures for women in both age groups were higher than recommended. The median figures for women of both age groups for saturated fats and mono-unsaturated fats were slightly higher than the recommendations, while for poly-unsaturated fats, the median intake of the older age group fell within the allowance (just

below the recommended 24 g). For cholesterol, the median intakes were higher than the guideline of less than 300 mg/day (Truswell, 1994).

Table 5.12: Energy, macronutrient and cholesterol intake in group 25-34 years of age

ENERGY, MACRONUTRIENTS AND CHOLESTEROL						
	Minimum	**Median**	**Mean**	**Maximum**	**RDA**	**<67% of RDA**
Energy (kJ)	1670.5	11475.4	12425.4	35312.1	9196	11.5
Total protein (g)	8.0	80.5	90.5	295.5	50	4.3
Plant protein (g)	2.9	34.4	38.8	126.1		
Animal protein (g)	2.4	40.5	48.1	209.3		
Total Carbohydrates (g)	51.3	339.4	375.8	1091.8	272-324	
Sucrose	1.4	53.5	60.2	194.9		
Starch (g)	0.9	19	30.6	341.6		

Table 5.12: Energy, macronutrient and cholesterol intake in group 25-34 years of age (Continued)

ENERGY, MACRONUTRIENTS AND CHOLESTEROL						
	Minimum	**Median**	**Mean**	**Maximum**	**RDA**	**<67% of RDA**
Total dietary fibre (g)	1.5	21.9	24.9	85.4	20-30	
Total fat (g)	14.4	99.4	106.3	371.2	<73	
Saturated fat (g)	4.5	28	30.8	122.2	<24	
Polyunsaturated fat (g)	2.7	26.7	29.9	103.5	<24	
Mono-unsaturated fat (g)	3.9	32.1	35	132.9	<24	
Cholesterol (mg)	13.2	317.9	377.9	1480	<300mg	

Table 5.13: Energy, macronutrient and cholesterol intake in group 35-44 years of age

ENERGY, MACRONUTRIENTS AND CHOLESTEROL						
	Minimum	**Median**	**Mean**	**Maximum**	**RDA**	**<67% of RDA**
Energy (kJ)	2646.8	10780.4	11392.9	26782.1	9196	12
Total protein (g)	12.8	77.9	81.7	215.6	50	6
Plant protein (g)	4.7	32.2	35.6	107.8		
Animal protein (g)	0	40.6	43.6	154.9		
Total carbohydrates (g)	78.8	317.3	352.6	949.5	272-324	

Table 5.13: Energy, macronutrient and cholesterol intake in group 35-44 years of age (Continued)

ENERGY, MACRONUTRIENTS AND CHOLESTEROL						
	Minimum	**Median**	**Mean**	**Maximum**	**RDA**	**<67% of RDA**
Sucrose	2.2	53.3	61.2	236.4		
Total dietary fibre (g)	2.3	20.9	22.7	72.3	20-30	
Total fat (g)	12.4	88.5	94	318.3	<73	
Saturated fat (g)	3.8	26	26.7	81.6	<24	
Polyunsaturated fat (g)	2.7	23.2	26.6	133.6	<24	
Mono-unsaturated fat (g)	4	29.6	31.1	92.8	<24	
Cholesterol (mg)	3.3	296	339.3	1928.8	<300mg	

5.3.2.2 MACRONUTRIENT INTAKE AS PERCENTAGE OF TOTAL ENERGY

The intake of energy, macronutrients and cholesterol as percentage of total energy for women of the two age groups are indicated in Tables 5.14 and 5.15.

The total recommended carbohydrate allowance for women of both age groups was taken as 50-60% of the RDA for total energy intake (Wolmarans et al., 1988). The median carbohydrate intake of both age groups compared well with recommended allowances. The median dietary fibre intake of 21.9 g and 20.9 g for the younger and older age groups respectively, fell within the recommended 20-30 g/day (Truswell, 1994).

The recommended total fat allowance for both age groups was considered as 30% of the RDA for total energy intake (Krummel, 2000, pp. 579-584)). It is further recommended that poly-unsaturated fats should constitute 10%, mono-unsaturated fats >10% and saturated fats <10% of the total fat allowance.

The median total protein intake as percentage of the total energy intake for both age groups fell within the recommended 12-20% of the total daily energy intake (Wolmarans et al., 1988).

Animal and plant proteins both contributed median figures of 5% of total energy intake for women of the two age groups.

Median total fat intakes contributed 32% and 31% of the total energy intake for the younger and older age groups respectively. These values are slightly higher than the recommended 30% of the total energy intake per day (Krummel, 2000, pp. 579-584). Saturated fats contributed a median intake of 9% of the total energy intake for both age groups, mono-unsaturated fats 10% for both age groups, and poly-unsaturated fats 9% and 8% respectively for the younger and older age groups.

The median total carbohydrate intake of 51% and 53% for the younger and older age group respectively, fell within the recommended 50-60% of the total daily energy intake.

Table 5.14: Intake as percentage of total energy of group 25-34 years of age

	Minimum %	Median %	Maximum %	Recommended intake %
Total protein	7	12	22	12-20
Plant protein	2	5	10	
Animal protein	1	6	19	
Total fats	10	32	54	<30
Saturated fats	2	9	18	<10TE
Mono-unsaturated fats	3	10	21	>10TE
Poly-unsaturated fats	3	9	26	10TE
Total carbohydrates	33	51	77	50-60
Total sucrose	1	12	39	

Table 5.15: Intake as percentage of total energy of group 35-44 years of age

	Minimum %	Median %	Maximum %	Recommended intake %
Total protein	4	12	24	12-20
Plant protein	2	5	11	
Animal protein	0	6	20	
Total fats	8	31	53	<30
Saturated fats	2	9	17	<10TE
Mono-unsaturated fats	3	10	19	>10TE
Poly-unsaturated fats	2	8	23	10TE
Total carbohydrates	31	53	83	50-60
Total sucrose	2	13	37	

5.3.2.3 MINERALS AND TRACE ELEMENTS

Tables 5.16 and 5.17 reflect the mineral and trace element intake for women of the two age groups respectively. All values are compared to RDA's, except for calcium and chromium, where recommendations are adequate intakes (AI: indicated with *). The most recent RDA and AI as published by Trumbo et al. (2001) and Monsen (2000), have been used for comparison.

Table 5.16: Mineral and trace element intake of group 25-34 years of age

MINERALS AND TRACE ELEMENTS						
	Minimum	**Median**	**Mean**	**Maximum**	**RDA / AI**	**<67% of RDA / AI ***
Calcium (mg)	113.4	626.9	747.3	2855.4	1000*	52.7*
Chromium (µg)	0.9	41.4	48.4	294.3	25*	10.8*
Copper (mg)	0.2	1.5	1.7	8.1	9	100
Iron Haem (mg)	0	0.4	0.6	5.6		
Iron non-haem (mg)	0	3.6	4.2	16.5		
Total iron (mg)	2.2	12.2	15.1	65.8	18	49.1
Iodine (µg)	1.1	40.5	46.6	187.7	150	94.6
Potassium (mg)	388.7	2902.3	3152	10053.7	2000	
Magnesium (mg)	40.2	365.5	279	1364.9	310	12.2
Manganese (µg)	145.5	3053.1	3589.6	14023.7	1800	6.5
Sodium (mg)	401.8	2659	2890.7	9896.6	3000	
Phosphorus (mg)	191.2	1331.2	1486.6	4903.6	700	3.2
Selenium (µg)	1.1	37.3	44.4	232.6	55	49.1
Zinc (mg)	0.5	10.3	11.5	38	8	11.1

The median calcium intake for women of both age groups was low, with 52.7% of women from the young group, and 53% women from the older group showing intakes that fell below 67% of the AI. The median chromium, potassium, manganese, and phosphorus intakes for both groups were high, with phosphorus intakes almost double that of the recommended 700 mg/day. The median intake of magnesium was adequate for the older group of women, while the RDA was not met by women in the younger age group. The profile of copper, total iron, selenium, and iodine reflects low median intakes

of these trace elements. For all subjects in both age groups, the intake of copper was less than 67% of the RDA. From the young group of women, 49.1%, and from the older group of women 53.5%, showed total iron intakes below 67% of the RDA. For iodine, the figures were even higher, with 94.6% of the women in the young group, and 96.8% of the women in the older group, taking less than 67% of the RDA. The median intake of sodium in both age groups seemed to be satisfactory if compared with the recommended 3000 mg/day (Truswell, 1994). Although the maximum intake of zinc was very high for both subject groups, the median intake seemed to be adequate.

Table 5.17: Mineral and trace element intake of group 35-44 years of age

MINERALS AND TRACE ELEMENTS						
	Minimum	**Median**	**Mean**	**Maximum**	**RDA / AI**	**<67% of RDA / AI ***
Calcium (mg)	72.8	636.4	729.4	2890.3	1000 *	53*
Chromium (µg)	0.8	41	49.5	227.8	25*	11.5*
Copper (mg)	0.3	1.4	1.5	5	9	100
Iron Haem (mg)	0	0.3	0.4	4		
Iron non-haem (mg)	0	3.4	3.9	15.4		
Total iron (mg)	2.1	11.4	12.8	73.1	18	53.5
Iodine (µg)	0.9	36.7	42.8	241.1	150	96.8
Potassium (mg)	651.3	2731.7	2891.8	6982.5	2000	

Table 5.17: Mineral and trace element intake of group 35-44 years of age (Continued)

MINERALS AND TRACE ELEMENTS						
	Minimum	Median	Mean	Maximum	RDA / AI	<67% of RDA / AI *
Magnesium (mg)	75.4	365.6	386.8	954.1	320	13.8
Manganese (µg)	448.5	2795.2	3086.1	9973	1800	7.8
Sodium (mg)	207.5	2332.2	2450.7	10617.8	3000	
Phosphorus (mg)	289.6	1294.5	1362	3430	700	1.8
Selenium (µg)	2	35.9	41.8	176.9	55	52
Zinc (mg)	1.2	9.6	10.4	36.5	8	11.5

5.3.2.4 VITAMINS

RDA's and AI published by Trumbo et al. (2001) and Monsen (2000) were used throughout for comparison.

i) FAT-SOLUBLE VITAMINS

The intake of fat-soluble vitamins for women in the two age groups are documented in Tables 5.18 and 5.19 respectively. Recommendations for vitamin A and E are RDA's, while recommendations for vitamin D and K are adequate intakes (AI: indicated with *).

Although the median intakes of vitamin A, D and E were slightly lower than recommendations for both age groups, these figures were close to the recommended

intake. The median intake for Vitamin K was high for both the younger and older age groups. The percentages of women from both age groups taking in less than 67% of the RDA for Vitamin A and E, and less than 67% of the AI for Vitamin D and K, were however high.

Table 5.18: Fat-soluble vitamin intake of group 25-34 years of age

FAT-SOLUBLE VITAMINS						
	Minimum	**Median**	**Mean**	**Maximum**	**RDA / AI***	**<67% of RDA / AI***
Vitamin A Re (µg)	48.8	687.3	949.5	5933.8	700	30.1
Vitamin D (µg)	0	4.9	5.9	36.3	5*	29.4*
Vitamin E (mg)	0.8	15.3	18.1	74.4	15	27.2
Vitamin K (µg)	0.1	123	184	1289.2	90*	20.8*

Table 5.19: Fat-soluble vitamin intake of group 35-44 years of age

FAT-SOLUBLE VITAMINS						
	Minimum	**Median**	**Mean**	**Maximum**	**RDA / AI***	**<67% of RDA / AI***
Vitamin A Re (µg)	85	697.5	931.6	5197.8	700	25.4
Vitamin D (µg)	0.3	4.5	5.3	31.8	5*	36.9*
Vitamin E (mg)	1.3	13.6	16.4	92.6	15	29
Vitamin K (µg)	0.2	126.6	220.3	1992	90*	17.1*

ii) WATER-SOLUBLE VITAMINS

The intake of water-soluble vitamins of women in the two age groups can be seen in Tables 5.20 and 5.21. All values are RDA's, except for vitamin B12, pantothenic acid and biotin, where recommendations are adequate intakes (AI: indicated with *).

Although median intakes of thiamin, riboflavin, niacin, vitamin B12, pantothenic acid and biotin for both age groups exceeded the RDA and AI respectively, and thus can be considered adequate. The median folate and vitamin C intakes were however low for both groups, with a high percentage of subjects from both age groups showing intakes less than 67% of the RDA (56.6% and 62.2% respectively for folate, and 46% and 53.9% respectively for vitamin C).

Table 5.20: Water-soluble vitamin intake of group 25-34 years of age

WATER-SOLUBLE VITAMINS						
	Minimum	**Median**	**Mean**	**Maximum**	**RDA / AI ***	**<67% of RDA / AI ***
Thiamin (mg)	0.3	1.7	1.8	10.3	1.1	9.3
Riboflavine (mg)	0.3	2.1	2.6	3776	1.1	5
Niacin (mg)	4	20.5	23.2	94	14	8.6
Vitamin B6 (mg)	0.3	1.5	1.7	9.4	1.3	19.4
Folate (µg)	31.1	241.5	285.1	1525.3	400	56.6
Vitamin B12 (µg)	0.2	5.1	7.3	50.2	2.4*	7.5*
Vitamin C (mg)	3.2	54.8	84.8	1424.4	75	46.2
Pantothenic acid (mg)	0.4	5.5	6.5	21.6	5*	15.4*

Table 5.20: Water-soluble vitamin intake of group 25-34 years of age (Continued)

WATER-SOLUBLE VITAMINS						
	Minimum	**Median**	**Mean**	**Maximum**	**RDA / AI ***	**<67% of RDA / AI ***
Biotin (µg)	1.9	35.7	43	325.1	30*	17.2*

Table 5.21: Water-soluble vitamin intake of group 35-44 years of age

WATER-SOLUBLE VITAMINS						
	Minimum	**Median**	**Mean**	**Maximum**	**RDA / AI***	**<67% of RDA / AI***
Thiamin (mg)	0.3	1.5	1.6	8.6	1.1	9.7
Riboflavine (mg)	0.2	1.8	2.2	9.8	1.1	6.5
Niacin (mg)	2.2	18.6	19.8	106.1	14	11.5
Vitamin B6 (mg)	0.2	1.2	1.4	12	1.3	24.9
Folate (µg)	40.8	234.3	265.4	1467.2	400	62.2
Vitamin B12 (µg)	0.1	4.6	5.8	30.7	2.4*	6.9*
Vitamin C (mg)	3.5	45.4	72.2	1690.7	75	53.9
Pantothenic acid (mg)	0.6	5.3	5.9	16.8	5*	17*
Biotin (µg)	4	33.4	38.2	154.2	30*	17*

5.3.3 THIRTY MOST FREQUENTLY CONSUMED FOODS BY MASS

The average intakes by mass of the thirty most frequently consumed foods for women in the two age groups are presented in Tables 5.22 and 5.23. The thirty foods most frequently consumed by mass by the two age groups, were very similar, with English tea, fresh / whole milk, followed by maize porridge and coffee, ranking highest on the list. According to the list analysis, it seemed that beverages formed 25-30% of the thirty most frequently consumed foods by mass. Typical Western foods such as fizzy drinks and Squash (Lecol / Oros), appeared high on the list of popular foods consumed by women of both age groups.

The high consumption pattern of alcoholic drinks, namely beer, by women of both age groups, is a matter of concern. The traditional home-brewn Motogo / Mageau, and sorghum beer seemed to be popular choices in women of both age groups.

Popular fruit choices of women of both age groups were apples, bananas and oranges, while women from the younger age group also included fresh fruit juices. Vegetables included in the lists, were spinach cooked with onion and potato, cabbage cooked with potato, onion and margarine, and french fries.

Red meat did not appear under the thirty most frequently foods consumed by either of the two age groups. Roasted chicken, dark and light meat, appeared low on the lists of popular foods of women in both age groups (number 28), while offal was only included in the list of the older women.

The consumption of refined starches, such as white rice, white bread, vetkoek, french fries and maize porridge under the thirty most frequently consumed foods by mass, can be seen as a move away from the typical African diet, high in fibre. Samp-and-beans, a traditional food preference of Africans, seemed to still be a popular food choice.

It became evident from these lists that vegetable oil and fat intake through the consumption of vetkoek and french fries is fairly high.

Table 5.22: Average intake by mass of the thirty most frequently consumed foods for the age group 25-34 years

Age group 25-34 years (n = 279)		
Number	**Food item**	**Average intake / day in g**
1	English tea	93539
2	Soft maize-meal porridge	88344
3	Whole / fresh milk	64288
4	Coffee	59315
5	Stiff maize-meal porridge	42116
6	Fizzy drinks	29525
7	Rooibosch tea	28872
8	Beer – average	26898
9	Brown bread	24810
10	Mabella porridge	19162
11	Lecol / Oros	12753
12	White Sugar	12199
13	Apple	10551

Table 5.22: Average intake by mass of the thirty most frequently consumed foods for the age group 25-34 years (Continued)

Age group 25-34 years (n = 279)		
Number	**Food item**	**Average intake / day in g**
14	Banana	10312
15	Samp and beans	9378
16	Sorghum beer	8996
17	White rice	7835
18	White bread	7645
19	Fresh fruit juice	7143
20	Oranges	7098
21	Vetkoek	6917
22	Spinach cooked with onion and potato	6356
23	Oats porridge	6306
24	Crumbly maize-meal porridge	5901
25	French fries	5586
26	Mageau/Motogo	5177
27	Cabbage boiled with potato, onion and margarine	4662
28	Chicken roasted, light and dark meat	4624
29	Cold drink low-cal/ Diet squash	4325
30	Cider	4308

Table 5.23: Average intake by mass of the thirty most frequently consumed foods for the age group 35-44 years

Age group 35-44 years (n = 217)		
Number	**Food item**	**Average intake / day in g**
1	English tea	97901
2	Whole / fresh milk	61476
3	Soft maize-meal porridge	57017
4	Stiff maize-meal porridge	50592
5	Coffee	43008
6	Beer – average	23787
7	Rooibosch tea	17338
8	Mabella porridge	15328
9	Brown bread	14549
10	Fizzy drinks	13332
11	White sugar	10641
12	Samp and beans	8934
13	Lecol / Oros	7629
14	White bread	7520
15	Mageau / Motogo	7386
16	Apple	7230
17	Orange	6252
18	Spinach cooked with onion and potato	6132
19	Banana	5839
20	Oats porridge	5224
21	White rice	5037
22	Vetkoek	4973

Table 5.23: Average intake by mass of the thirty most frequently consumed foods for the age group 35-44 years (Continued)

Age group 35-44 years (n = 217)		
Number	**Food item**	**Average intake / day in g**
23	Sorghum beer	4039
24	Cabbage boiled with potato, onion and margarine	4620
25	French fries	3790
26	Offal	3726
27	Pear	3715
28	Chicken roasted, light and dark meat	3597
29	Cold drink low-cal/ Diet squash	3119
30	Crumbly maize-meal porridge	3019

5.4 BIOCHEMICAL PARAMETERS

Results of fasting triglycerides (TG), cholesterol, serum albumin, serum glucose, and serum insulin follow.

5.4.1 BIOCHEMICAL ANALYSIS

The Biochemical Analysis of women is presented in Tables 5.24 and 5.25.

Table 5.23: Average intake by mass of the thirty most frequently consumed foods for the age group 35-44 years (Continued)

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5.4 BIOCHEMICAL PARAMETERS

Results of fasting triglycerides (TG), cholesterol, serum albumin, serum glucose, and serum insulin follow.

5.4.1 BIOCHEMICAL ANALYSIS

The Biochemical Analysis of women is presented in Tables 5.24 and 5.25.

Table 5.24: Biochemical analysis of women in the age group 25-34 years

Biochemical parameters	Age group 25-34 years			
	N	Q1	Median	Q3
Serum Glucose (mmol/l)	276	3.9	4.3	4.7
Serum Insulin (μU/ml)	276	3.0	7.0	15.5
Insulin Sensitivity	275	144.5	325.3	755.3
Total Cholesterol (mmol/l)	277	3.6	4.2	4.9
TG (mmol/l)	277	0.7	0.9	1.2
Albumin (g/l)	277	38.8	41.3	44.3

Values for serum glucose, serum insulin, total cholesterol, TG and albumin (Q1, median and Q3) fell within the normal ranges for women of the younger group.

Table 5.25: Biochemical analysis of women in the age group 35-44 years

Biochemical parameters	Age group 35-44 years			
	N	Q1	Median	Q3
Serum Glucose (mmol/l)	217	4	4.4	4.9
Serum Insulin (μU/ml)	217	2.5	6.3	10.7
Insulin Sensitivity	217	206.0	390.4	977.5
Total Cholesterol (mmol/l)	216	3.9	4.5	5.3
TG (mmol/l)	216	0.8	1.1	1.5
Albumin (g/l)	215	38.9	41.5	43.6

Values for serum glucose, serum insulin, TG and albumin (Q1, median and Q3) fell within their normal ranges for women of the older group, while the value for total cholesterol in Q3 was slightly higher than the normal value of 0.9-5.2 mmol/l.

5.4.2 FASTING TG

The fasting TG values of women of both age groups are presented in Table 5.26. Most women in the two age groups had normal (<2 mmol/l) fasting TG levels. Fasting TG levels tended to increase with an increase in age.

Table 5.26: TG values

	TG			
	<2 mmol/l (Normal)		≥2 mmol/l (High)	
Age group	**N**	**% of total group**	**N**	**% of total group**
25-34 years (n = 279)	260	93.2	19	6.8
35-44 years (n = 217)	187	86.2	30	13.8

5.4.3 FASTING TOTAL CHOLESTEROL

The fasting total cholesterol values of women of both age groups are presented in Table 5.27.

Table 5.27: Total cholesterol values

	>0.9<5.2 mmol/l Normal		5.2<7.8 mmol/l Moderate risk		≥7.8 mmol/l High risk	
Age group	**N**	**% of total group**	**N**	**% of total group**	**N**	**% of total group**
25-34 years (n = 277)	221	79.8	44	15.9	12	4.3
35-44 years (n = 216)	154	71.3	60	27.8	2	0.9

A large proportion of women (79.8% and 71.3% from the two age groups respectively), had normal fasting cholesterol levels. More women from the older age group (27.8%) fell in the moderate risk group, while the percentage of women in the high risk category was relatively low.

5.4.4 FASTING SERUM ALBUMIN

The fasting serum albumin values of women of both age groups are presented in Table 5.28. Almost all the women in the two age groups had normal (34-48 g/l) fasting serum albumin levels.

Table 5.28: Serum albumin values

	<34 g/l (Low)		34-48 g/l (Normal)		≥48 g/l (High)	
Age group	**N**	**% of total group**	**N**	**% of total group**	**N**	**% of total group**
25-34 years (n = 277)	0	0.0	273	98.6	4	1.4
35-44 years (n = 215)	1	0.5	214	99.5	0	0.0

5.4.5 FASTING SERUM GLUCOSE

The fasting serum glucose values of women of both age groups are presented in Table 5.29.

Fasting serum glucose levels fell within the normal range of 3.05-6.38 mmol/l for most women. More women from the young age group, compared to the older group showed high fasting serum glucose levels (10.5% and 4.2% respectively).

Table 5.29: Serum glucose values

	<3.05 mmol/l (Low)		3.05-6.38 mmol/l (Normal)		>6.38 mmol/l (High)	
Age group	**N**	**% of total group**	**N**	**% of total group**	**N**	**% of total group**
25-34 years (n = 277)	15	5.4	232	84.1	29	10.5
35-44 years (n = 215)	13	6	195	89.9	9	4.2

5.4.6 FASTING SERUM INSULIN

The fasting serum insulin values of women of both age groups are presented in Table 5.30.

Table 5.30: Serum insulin values

	<25µU/ml (Normal)		≥25µU/ml (High)	
Age group	**N**	**% of total group**	**N**	**% of total group**
25-34 years (n = 276)	243	88.0	33	12
35-44 years (n = 217)	194	89.4	23	10.6

The largest proportion of women showed normal serum insulin levels (<25μU). As seen with fasting glucose, more women from the younger group had high serum insulin levels (12% and 10.6% respectively).

5.5 ASSOCIATIONS

The following associations were determined:

- Fasting glucose and waist circumference;
- BMI and TG;
- Insulin sensitivity and BMI;
- Insulin sensitivity and WHR;
- Insulin sensitivity and TG.

5.5.1 ASSOCIATION BETWEEN FASTING GLUCOSE AND WAIST CIRCUMFERENCE OF WOMEN

The association between fasting glucose and waist circumference of both groups of women is presented in Table 5.31.

To determine whether waist circumference is associated with the fasting glucose level, a 2 x 2 table of categorised waist circumference and categorised glucose level was constructed, and the risk of a high blood glucose level in the waist circumference categories was compared by a Jeffreys-Perks CI for the difference between independent percentages (Newcombe, 1998).

Of the total 279 younger women, 29 had an elevated fasting glucose. Of the 29 women with an elevated fasting glucose, 21 (72.4%) had a waist circumference smaller than 88 cm, and 8 (27.6%) had a waist circumference equal to, or above 88 cm. No significant association between waist circumference and elevated glucose was found (CI -3.67 ; 17.5).

Of the total 217 older women, only nine had an elevated fasting glucose. The small numbers make it difficult to draw conclusions. Of those with an elevated glucose, 5 had a waist circumference smaller than 88 cm and 4 had a waist circumference equal to or bigger than 88 cm. None of the associations were significant (CI -2.7 ; 11.6).

Table 5.31: The association between fasting glucose and waist circumference

	<35 years		≥35 years	
Parameter	**N**	**% of total group**	**N**	**% of total group**
Waist circumference <88 cm Glucose above normal	21	72.4	5	55.6
Waist circumference ≥88 cm Glucose above normal	8	27.6	4	44.4
95 % CI for difference between percentages	(-3.67 ; 17.5)		(-2.7 ; 11.6)	

5.5.2 ASSOCIATION BETWEEN BMI AND TG

The association between BMI and TG of both groups of women is presented in Table 5.32. Of the 274 younger women, 16 had elevated TG levels. Of those 16, 1 had a BMI <18.5, 3 had a BMI of 18.5 ≤ 25, 5 had a BMI ≥ 30, and 7 had a BMI ≥ 30.

Of the 217 older women, 30 had elevated TG levels. Of these 30, 11 had a BMI 18.5 ≤ 25, 10 had a BMI 25 ≥ 30, and 9 had a BMI ≥.

A Spearman correlation of 0.16 indicated that there was no correlation between TG levels and BMI in this group.

Table 5.32: Association between BMI and TG

	<35 years				≥35 years			
BMI categories	**Normal TG**		**High TG**		**Normal TG**		**High TG**	
	N	**% of total group**	**N**	**% of total group**	**N**	**% of total group**	**N**	**% of total group**
BMI <18.5	6	85.71	1	14.29	9	100	0	0.00
BMI 18.5<25	118	97.52	3	2.48	85	88.54	11	11.46
BMI 25<30	77	93.90	5	6.10	50	83.33	10	16.67

Table 5.32: Association between BMI and TG (Continued)

	<35 years				≥35 years			
BMI categories	**Normal TG**		**High TG**		**Normal TG**		**High TG**	
	N	**% of total group**	**N**	**% of total group**	**N**	**% of total group**	**N**	**% of total group**
BMI ≥30	57	89.06	7	10.94	43	82.69	9	17.31

5.5.3 ASSOCIATION BETWEEN BMI AND INSULIN SENSITIVITY

The association between BMI and insulin sensitivity for women in the younger age group, is presented in Table 5.33.

Insulin sensitivity was calculated using the following equation: (10000 / (glucose x insulin)) (Donahue et al., 1988), and categorised into quartiles. The number of subjects in each quartile group ranged from 68 in group 1, to 69 in groups 2, 3, and 4. In group 1 with the lowest insulin sensitivity (thus highest insulin resistance), the median BMI was 27.6 kg/m^2. As insulin sensitivity improved, the median BMI decreased (group 1 to 4). In group 4, the most insulin sensitive group, the median BMI was the lowest (23 kg/m^2).

When the medians of BMI were compared between all insulin sensitivity quartiles by 95% non-parametric CI for the median difference, significant differences were found in insulin sensitivity of groups 1 and 4 (CI 1.91 ; 5.38), groups 2 and 4 (CI 1.40 ; 4.73), and groups 3 and 4 (CI 1.41 ; 4.51).

Table 5.33: Association between BMI and insulin sensitivity of women in age group 25-34 years

Parameter	Insulin sensitivity Group 1 12.13≤144.47	Insulin sensitivity Group 2 <144.47≤325.28	Insulin sensitivity Group 3 <325.28≤755.34	Insulin sensitivity Group 4 >755.34
BMI				
N	68	69	69	69
Median	27.6	26.7	26.3	23.0
Q1	23.2	22.6	23.2	20.8
Q3	31.6	30.7	30.3	25.8

Parameter	Median difference		95% non-parametric CI for median difference
BMI	Group1-Group 2	0.51	-1.33 ; 2.28
	Group1-Group 3	0.63	-1.26 ; 2.48
	Group1-Group 4	3.51	1.91 ; 5.38 *
	Group2-Group 3	0.10	-1.73 ; 1.87
	Group2-Group 4	3.05	1.40 ; 4.73 *
	Group3-Group 4	2.92	1.41 ; 4.51 *

* Mean values with the same symbol differ significantly between groups

The association between BMI and insulin sensitivity of women in the older group is presented in Table 5.34. The number of subjects in each quartile group ranged from 53 in group 2, 54 in group 3, and 55 in groups 1 and 4. In the group (group 1) with the

lowest insulin sensitivity, the BMI was 26.2 kg/m^2. In group 4, the most insulin sensitive group, the BMI was 23.5 kg/m^2.

Table 5.34: Association between BMI and insulin sensitivity of women in age group 35-44 years

Parameter	**Insulin sensitivity Group 1 14.10≤206.01**	**Insulin sensitivity Group 2 >206.01≤309.39**	**Insulin sensitivity Group 3 >390.39≤977.52**	**Insulin sensitivity Group 4 >977.52**
BMI				
N	55	53	54	55
Median	26.2	26.0	26.5	23.5
Q1	22.4	22.2	23.3	20.2
Q3	31.4	30.2	31.2	25.6

Parameter	**Median difference**		**95% non-parametric CI for median difference**
BMI	Group1-Group 2	0.61	-1.80 ; 2.87
	Group1-Group 3	-0.08	-2.20 ; 2.23
	Group1-Group 4	3.24	1.24 ; 5.27 *
	Group2-Group 3	-0.42	-2.81 ; 1.60
	Group2-Group 4	2.84	0.79 ; 4.88 *
	Group3-Group 4	3.30	1.60 ; 5.24 *

* Mean values with the same symbol differ significantly between groups

When the medians of BMI were compared between all insulin sensitivity quartiles by 95% non-parametric CI for the median difference (Table 5.34), the following was found:

Within the younger group (25-34 years), it was found that there exist statistically significant differences between the BMI's of the different quartiles of insulin sensitivity (groups 1 and 4: CI 1.24 ; 5.27, groups 2 and 4: CI 0.79 ; 4.88, and groups 3 and 4: CI 1.60 ; 5.24).

5.5.4 ASSOCIATION BETWEEN WHR AND INSULIN SENSITIVITY

The association between WHR and insulin sensitivity for women in the age group 25-34 years, is presented in Table 5.35.

Table 5.35: Association between WHR and insulin sensitivity of women in age group 25-34 years

Parameter	Insulin sensitivity Group 1 12.13≤144.47	Insulin sensitivity Group 2 <144.47≤325.28	Insulin sensitivity Group 3 <325.28≤755.34	Insulin sensitivity Group 4 >755.34
WHR				
N	68	69	69	69
Median	0.74	0.73	0.74	0.74
Q1	0.69	0.71	0.67	0.69
Q3	0.79	0.78	0.77	0.76

Table 5.35: Association between WHR and insulin sensitivity of women in age group 25-34 years (Continued)

Parameter	Median difference		95% non-parametric CI for median difference
WHR	Group1-Group 2	0.0019	-0.02 ; 0.03
	Group1-Group 3	0.016	-0.01 ; 0.04
	Group1-Group 4	0.009	-0.01 ; 0.03
	Group2-Group 3	0.009	-0.02 ; 0.04
	Group2-Group 4	0.005	-0.01 ; 0.02
	Group3-Group 4	-0.002	-0.02 ; 0.02

* Mean values with the same symbol differ significantly between groups

The association between WHR and insulin sensitivity of women in age group 35-44 years is presented in Table 5.36. The median WHR of the older women in the 4 quartiles were 0.76 in group 4, 0.77 in group 3, 0.78 in group 2, and 0.79 in group 1. When the medians of WHR were compared between all insulin sensitivity quartiles by 95% non-parametric CI for the median difference, a significant difference was found between the insulin sensitivity of groups 1 and 4 (CI 0.01 ; 0.06).

Table 5.36: Association between WHR and insulin sensitivity of women in age group 35-44 years

Parameter	Insulin sensitivity Group 1 14.10≤206.01	Insulin sensitivity Group 2 >206.01≤390.39	Insulin sensitivity Group 3 >390.39≤977.52	Insulin sensitivity Group 4 >977.52
WHR				
N	55	53	54	55
Median	0.79	0.78	0.77	0.76
Q1	0.74	0.74	0.72	0.72
Q3	0.84	0.82	0.81	0.81

Parameter	Median difference		95% non-parametric CI for median difference
WHR	Group1-Group 2	0.016	-0.01 ; 0.04
	Group1-Group 3	0.02	-0.001 ; 0.05
	Group1-Group 4	0.03	0.001 ; 0.06 *
	Group2-Group 3	0.01	-0.02 ; 0.04
	Group2-Group 4	0.01	-0.01 ; 0.04
	Group3-Group 4	0.002	-0.02 ; 0.03

* Mean values with the same symbol differ significantly between groups

5.5.5 ASSOCIATION BETWEEN TG AND INSULIN SENSITIVITY

The association between TG and insulin sensitivity for women in the age group 25-34 years, is presented in Table 5.37.

Table 5.37: Association between TG and insulin sensitivity of women in age group 25-34 years

Parameter	Insulin sensitivity Group 1 12.13≤144.47	Insulin sensitivity Group 2 <144.47≤325.28	Insulin sensitivity Group 3 <325.28≤755.34	Insulin sensitivity Group 4 >755.34
TG				
N	68	69	69	69
Median	1.08	0.92	0.83	0.91
Q1	0.71	0.68	0.62	0.66
Q3	1.52	1.22	1.12	1.15

Parameter	Median difference		95% non-parametric CI for median difference
TG	Group1-Group 2	0.14	-0.01 ; 0.31
	Group1-Group 3	0.20	0.06 ; 0.39 *
	Group1-Group 4	0.15	0.01 ; 0.32 *
	Group2-Group 3	0.07	-0.05 0.19
	Group2-Group 4	0.02	-0.11 ; 0.14
	Group3-Group 4	-0.05	-0.17 ; 0.07

* Mean values with the same symbol differ significantly between groups

The median TG levels of the younger women in the 4 quartiles were 0.83 in group 3, 0.91 in group 4, 0.92 in group 2 and 1.08 in group 1. When the medians of TG were compared between all insulin sensitivity quartiles by 95% non-parametric CI for the

median difference, a significant difference was found between the insulin sensitivity of groups 1 and 3 (CI 0.06 ; 0.39), and groups 1 and 4 (CI 0.01 ; 0.32).

The association between TG and insulin sensitivity for women in the age group 35-44 years, is presented in Table 5.38.

Table 5.38: Association between TG and insulin sensitivity of women in age group 35-44 years

Parameter	**Insulin sensitivity Group 1 14.10≤206.01**	**Insulin sensitivity Group 2 >206.01≤309.39**	**Insulin sensitivity Group 3 >390.39≤977.52**	**Insulin sensitivity Group 4 >977.52**
TG				
N	55	52	54	55
Median	1.27	0.98	1.08	1.11
Q1	0.93	0.82	0.81	0.78
Q3	1.71	1.35	1.47	1.41

Parameter	**Median difference**		**95% non-parametric CI for median difference**
TG	Group1-Group 2	0.22	0.03 ; 0.42 *
	Group1-Group 3	0.14	-0.06 ; 0.34
	Group1-Group 4	0.20	0.02 ; 0.40 *
	Group2-Group 3	-0.07	-0.25 ; 0.09
	Group2-Group 4	-0.01	-0.17 ; 0.16
	Group3-Group 4	0.06	-0.11 ; 0.23

* Mean values with the same symbol differ significantly between groups

The median TG levels of the older women in the 4 quartiles were 0.98 in group 2, 1.08 in group 3, 1.11 in group 4 and 1.27 in group 1. When the medians of TG were compared between all insulin sensitivity quartiles by 95% non-parametric CI for the median difference, a significant difference was found between the insulin sensitivity of groups 1 and 2 (CI 0.03 ; 0.42), and groups 1 and 4 (CI 0.02 ; 0.40).

5.6 SUMMARY

Anthropometric results included BMI, fat distribution and fat percentage. In the younger group, 53.4%, and in the older group, 51.7% had a BMI ≥ 25. Fat distribution indicated that most women (83.5% of the younger women, and 62.7% of the older women) had a gynoid fat distribution. The fat percentages of women from both age groups were high, with only 6.5% from the younger group, and 4.6% from the older group having normal fat percentages.

Median dietary intakes indicated that intakes for energy, protein, total fat, carbohydrates, and cholesterol were high. Median dietary fibre intakes were adequate.

When the median intake of the macro-nutrients was calculated as a percentage of the total daily energy intake, the median percentage of protein intake fell in the recommended 12-20% of the total daily energy intake, while the median percentage of total fat intake exceeded the recommendation of less than 30% for both age groups. The median percentage intake of saturated fats fell within the recommendations of less than 10%, while the median percentage intake of mono-unsaturated fats was 10% for women of both age groups. The median percentage intake of poly-unsaturated fats was lower than the recommended 10% for women of both age groups.

The median TG levels of the older women in the 4 quartiles were 0.98 in group 2, 1.08 in group 3, 1.11 in group 4 and 1.27 in group 1. When the medians of TG were compared between all insulin sensitivity quartiles by 95% non-parametric CI for the median difference, a significant difference was found between the insulin sensitivity of groups 1 and 2 (CI 0.03 ; 0.42), and groups 1 and 4 (CI 0.02 ; 0.40).

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Median intakes of the minerals and trace elements chromium, potassium, manganese, and phosphorus were high. Low median intakes were found for calcium, total iron, copper, iodine and selenium. Approximately 50% of all the women had intakes less than 67% of the AI and RDA respectively for calcium, total iron, and selenium. For magnesium, the younger group of women showed median intakes that fell below the RDA for magnesium, while the older group showed adequate median intakes.

Median intakes of the fat-soluble vitamins A, D, and E were slightly lower than recommendations, while Vitamin K intake was high. A fairly large percentage of women from both age groups however consumed less than 67% of the AI/RDA of these vitamins.

Median intakes of the water-soluble vitamins showed low intakes of vitamin C and folate, with about half of the respondents consuming less than 67% of the RDA for vitamin C and folate. Median intakes for thiamin, riboflavin, niacin, vitamin B6, vitamin B12, pantothenic acid, and biotin were adequate.

The lists of the thirty most frequently consumed foods by mass indicated that although traditional foods are still popular amongst these women, the effect of westernisation is clearly visible, with more Western foods and beverages now being chosen. A staple diet consisting of starch, grains and cereals is still followed by these women, but fat and sugar intake is high.

Biochemical parameters indicated that most women from the two age groups had normal fasting TG, serum albumin, serum glucose and serum insulin levels. Fasting cholesterol

levels seemed to increase with an increase in age, with 28.7% of the older women having cholesterol levels above normal.

A significant association between insulin sensitivity and BMI, and between insulin sensitivity and TG levels was found in this population. No associations were found between fasting glucose levels and waist circumference, and between insulin sensitivity and WHR.

CHAPTER 6

DISCUSSION OF RESULTS

6.1 INTRODUCTION

In this chapter, possible reasons for findings will be given, and where possible, results will be compared to other similar studies.

6.2 LIMITATIONS OF THE STUDY

Limitations experienced in the execution of the study will be discussed in the following sections.

6.2.1 SAMPLE

Initially it was planned that an equal number of women (250) would be included in each group. This objective was not met. The community health workers who were involved in contacting the respondents asked the subjects age, while in the actual study identification documents were used to obtain the correct age of the respondents. The younger sample thus consisted of 279 women, and the older sample consisted of 217 women. Four of the subjects were pregnant, and could not be included in the study.

6.2.2 VALIDITY AND RELIABILITY OF FFQ

Although the reliability of the FFQ was relatively good in this study, the validity of the FFQ was a limitation, which will be discussed later in this chapter (6.3.5.2).

6.2.3 DIETARY INTAKE

The question "Are we measuring what people eat?" arises when the dietary intake of people has to be assessed. To date, no single dietary assessment method has been described as the best method (Lee & Nieman, 1996, p 92; Dwyer, 1998, p. 937), indicating limitations that may be experienced with dietary assessment methods, including the FFQ.

A limitation of the validation study performed prior to the main study, was that the sample selected for the validation study was random and mostly illiterate. The information obtained from the weighed records of this sample was thus unusable.

According to literature, the successful administering of the FFQ depends on the ability of the subject to describe his/her diet (Lee & Niemann, 1996, p. 107). In this study, trained interviewers, together with Xhosa and Sotho interpreters were used to complete the FFQ in an interview with each respondent.

One of the disadvantages of the FFQ is that not all foods can be included in the lists, making it difficult to obtain the total food consumption of respondents (Dwyer, 1998, p. 943). The FFQ used in this study, however eliminated this problem by including an

additional section for habitual and cultural food preferences not listed under Western foods. An open section at the end of the FFQ allowed the respondent to further report any other foods not included in the FFQ.

The burden placed on the respondent may also increase, as the number of the food items queried increases (Dwyer, 1998, p. 943). Subjects however responded in a positive manner towards administering of the FFQ in this study. The fact that most respondents still eat a diet consisting mostly of individual foods or simple food combinations, also limited the complexity of answers, and made it easier to administer the questionnaire.

Although respondents were queried about the use of flavoured salts and beef and chicken stock in food preparation, information about the amount, and use of salt *per se* in food preparation, was not collected in our study.

The problem of under- and overestimation of foods consumed by respondents may occur with dietary assessment methods (Dwyer, 1998, p. 943), including the FFQ used in this study. Reported frequency of food use obtained by FFQ has however been shown to be reasonably accurate and valid in other studies (Lee & Nieman, 1996, p. 106). The FFQ is also a relatively inexpensive method to use with large sample sizes (Lee & Nieman, 1996, p. 107; Dwyer, 1998, p. 943), as was the case in this study. FFQ are good to use for describing food and nutrient intake of groups rather than for individuals (Dwyer, 1998, p. 945), and are commonly used in epidemiological research on diet and disease relationships (Willett, 1990). The FFQ was considered as a good method of dietary assessment to determine the actual dietary intake of the women included in this study.

6.2.4 BLOOD SAMPLES

A very small percentage of missing values was reported for total cholesterol, serum albumin, serum glucose, and serum insulin. The main cause for these missing values can be ascribed to difficulties in obtaining all the blood samples from some respondents. In very obese subjects it is sometimes difficult to obtain samples. Where the registered nurse was unable to obtain a sample, the medical practitioner assisted. Blood samples were obtained from most subjects. For total cholesterol, samples could not be obtained in two subjects of the younger group, and one subject of the older group. Samples for serum albumin and serum glucose could not be obtained in two subjects of each group, while samples for serum insulin could not be obtained for three of the respondents of the younger group.

6.3 DISCUSSION OF RESULTS: MAIN STUDY

6.3.1 ANTHROPOMETRY

The anthropometric results of BMI, WHR, and fat percentage assessments will be discussed in the following sections.

6.3.1.1 BODY MASS INDEX

The prevalence of overweight and obesity in the studied group of women was an outstanding anthropometric feature, with 53.3 percent, and 51.7 percent from the younger and older age groups respectively having a BMI higher than 25 (Table 5.1).

Obesity figures *per se* (BMI ≥ 30), ranged between 23.3 and 24 percent for the two age groups respectively, which was in contrast to findings from the QwaQwa-Mangaung study by Mollentze et al. (1995), in which prevalences ranged from 27.5 percent to 49 percent in QwaQwa women (age groups 25-65 years and older), and 31.1 percent to 54.3 percent in Mangaung women (25-65 years and older). Although our figures for women falling in the obese class were slightly lower than the figures reported by Mollentze et al. (1995), the percentage of women falling in the overweight category should also be a matter of concern, as overweight may eventually lead to obesity.

Statistics reported from the Coronary Heart Disease Risk Factor Study in the African Population of the Cape Peninsula (BRISK) study performed on African women in the Cape Peninsula (Steyn et al., 1991) revealed that the mean percentage of African women with a BMI above thirty was higher than the women in our study at 30.6 percent, and 47.7 percent respectively for women of the same age groups used in our study. Data obtained from three other large South African studies on Coloured women in the Coronary Risk Factor Study among the Coloured Population of the Cape Peninsula (CRISIC) (Steyn et al., 1990), Indian women (Seedat et al., 1990) and White women in the Coronary Risk Factors Resurvey (CORIS) study (Jooste et al., 1988), were all lower than figures reported for African women in other studies (Vorster et al., 1997).

6.3.1.2 WHR

Visceral fat in women is defined as a WHR higher than 0.80 centimeters (Hammond, 2000, p. 372). In this study, most women in both age groups had a WHR smaller than 0.80 centimeters, (Table 5.2) indicating a gynoid fat distribution. Mollentze et al. (1995), who studied the indigenous African populations of QwaQwa and Mangaung, found that a

subgroup of obese persons with central or android obesity are at greater risk of developing cardiovascular disease. In contrast to our findings, (mean WHR of 0.74 in the younger group and 0.78 in the older group), the mean WHR of women in both the populations studied by Mollentze et al. (1995), and for all age groups, exceeded 0.8. Another study performed in urban Africans in Cape Town, showed a mean WHR of 0.80 for women above the age of thirty years (Levitt et al., 1993). Van der Merwe et al. (1999), have also reported mean WHR of 0.80 for healthy, obese white and black South African women.

Fat distribution is affected by a number of factors, such as gender and ethnicity. Women in general have less central fat than men. This difference in genders might be an important contributor to the greater prevalence of diseases associated with central obesity in men compared with pre-menopausal women (Pi-Sunyer & Albu, 1999). A peripheral fat distribution shows relationships with less serious problems, such as joint disease and varicose veins due to mechanical problems associated with increased weight (Björntorp, 2001). Different ethnic groups might also accumulate abdominal fat differently as they gain weight (Pi-Sunyer & Albu, 1999). Conway et al. (1995) however reported mean WHR of 0.86 and 0.84 respectively, for black and white women in the USA, indicating that there were no significant differences between races. Treatment of particularly women in the older age group with central obesity, should receive high priority to decrease the risk of cardiovascular disease, type 2 diabetes, stroke, certain cancers, and premature mortality (Björntorp, 2001). An increase in physical activity will have a favourable effect on body fat distribution, resulting in a reduction in the WHR (Walker, 1995a) and abdominal obesity (Björntorp, 2001).

6.3.1.3 FAT PERCENTAGE

A matter that needs to be addressed urgently, is the total number of women who demonstrated extremely high fat percentages. Regardless of weight, almost all the subjects had a fat percentage higher than the recommended twenty to 25 percent (92.5 percent and 94 percent for the two age groups respectively). The mean fat mass percentage of healthy white and African obese women studied by Van der Merwe et al. (1999), using bio-electrical impedance analysis, was reported as 42.1 and 45 percent respectively. These figures are higher than the mean fat percentage of women in our study (36.6 percent and 39 percent for younger and older women respectively). High mean fat percentages (52.8 percent and 51.5 percent in black and white women respectively) were also reported from an international study by Conway et al. (1995). Although not reported in our study, levels of physical activity were extremely low in the women included in the study.

Although exercise in itself may not produce major weight losses, it helps to alter the body composition favourably by reducing fat, and increasing muscle. Increased physical activity is therefore a basic, necessary intervention (Caterson, 1998, p. 267-268) to be recommended on a national scale.

6.3.2 VALIDITY AND RELIABILITY OF FFQ

Validity and reliability of the FFQ will be discussed in the following sections.

6.3.2.1 RELIABILITY OF FFQ

The FFQ that was administered at the start of the reliability study also served as a pilot study. Results showed that the intakes of most nutrients differed with less than 10% between the initial and follow-up FFQ and were thus considered reliable. Although not statistically significant, mean percentage differences for fats (total fat, saturated fat, PUFA and MUFA) and fat-soluble vitamins (A,D,E and K), however exceeded 10%. Of interest is the consistently higher intakes reported in the second FFQ for all fats. These results are in accordance with those of other studies in developing countries where higher nutrient intakes were reported in a second evaluation (Romieu et al., 1997; Larkin et al., 1989). These authors have indicated that a second questionnaire may yield better results due to a learning effect resulting in the second questionnaire being completed in more detail.

When the FFQs used in the two surveys were compared it was found that the second FFQ included more detailed information on fats added during food preparation (lard, oil, margarine and butter). This would account for the variation in fat intake and fat-soluble vitamin intake reported in the two FFQs. In view of this finding, the trained interviewers were asked to give special attention to obtaining information about food preparation methods when undertaking the FFQ interviews in the main study.

Although not statistically significant, differences in mean percentage intakes for the micro-nutrients calcium, sodium, selenium, riboflavine, folate, vitamin C and biotin were also higher than 10%. As with fat intake, information in the second FFQ was found to be more comprehensive than that in the first FFQ with regard to milk added to foods and

meals (milk used in tea and coffee and added to porridge) which would account for differences in reported calcium and riboflavine intake. In addition, more detail was given in the second FFQ regarding the use of stocks, soups and other flavourants used in food preparation which could account for the small difference in sodium intake.

Variation in selenium and folate intake only just exceeded the chosen cut-off point of 10% in mean percentage difference between the two FFQs (12.32% for selenium and 10.78% for folate). The 95% CI for the mean percentage difference indicated that differences were not significant.

In contrast to the reported higher intakes of most nutrients in the second FFQ, the vitamin C content of the second FFQ was lower than that reported initially (-20.41%). The reason for this finding is uncertain.

6.3.2.2 VALIDITY OF FFQ

In contrast to reliability, many researchers agree that validation of an instrument used to determine dietary intake is not accurately possible (Larkin et al., 1989). Weighed records are considered by many to be the "gold standard" against which to compare dietary intake obtained using a different instrument such as a FFQ or a 24-hour recall. However, no dietary assessment method can safely be qualified as the ideal (Livingston, 1995; Bonifacj et al., 1997; Coates and Monteilh, 1997). Furthermore, the validity of an instrument used to record dietary intake is influenced by the recording process itself (Livingston, 1995; Stuff et al., 1983).

Other validation studies undertaken in developing communities have yielded results similar to ours, in that intakes reported using the FFQ were significantly higher than those reported using other methods of dietary intake assessment, such as 24-hour recall (Romieu et al., 1997), dietary recall and records (Larkin et al., 1989) or weighed records (Coates and Monteilh, 1997).

In contrast to the random sample used in our study, most validation studies have been undertaken in literate populations that are very closely monitored (Livingston, 1995; Larkin et al., 1989; Stuff et al., 1983; Bingham et al., 1994). Even so, the results of these studies often give conflicting results. For the validation of the FFQ used in the THUSA study in SA, a sample specifically selected for literacy was used (MacIntyre, 2001).

According to Livingston (1995) "the choice of method for an epidemiological study where dietary data may be obtained on hundreds of individuals will be based on the design and objectives of the study and the nature of the information required." FFQ have widely been recommended for epidemiological studies (Coates and Monteilh, 1997) such as this one. To investigate relationships between nutrient intake and disease a description of dietary intake over time is required (Larkin et al., 1989). In view of the above we are of the opinion that the results obtained using the FFQ are of value despite the fact that it could not be validated.

6.4 DIETARY INTAKE

The intake of energy, macronutrients, minerals and trace elements, water- and fat-soluble vitamins, and thirty most frequently consumed foods, will be discussed.

6.4.1 ENERGY INTAKE

The mean energy intake of women in both age groups was markedly higher than the results obtained from other studies utilizing food frequency questionnaires, in South Africa and overseas (Bingham et al., 1994; Bonifacj et al., 1997; Larkin et al., 1989; Stuff et al., 1983; Romieu et al., 1997; Vorster et al., 1997). This may account for the high prevalence of obesity seen in our sample. A significant difference between the energy intake of rural and urban black women has been reported by Vorster et al. (1997), with urban women taking in more kilojoules than their rural counterparts. Although it is difficult to compare mean intake of nutrients obtained by means of other dietary assessment methods, total mean energy intake in this study was higher than a similar study performed on black women in South Africa, where the 24-hour recall method was used (Bourne et al., 1993). The tendency for persons to over-report low intakes, and to under-report high intakes of foods may be encountered with the 24-hour recall method (Dwyer, 1998, p. 943; Hammond, 2000, p. 369; Lee & Nieman, 1996, p. 99; Pressman & Adams, 1990, p. 36).

The transition to a westernized lifestyle, usually leads to an increased consumption of energy-dense diets (O'Dea, 1991), which was observed in this study. Urban Africans are exposed to a more diverse diet than their rural counterparts, which may lead to the high total energy intake. The increasing number of street food vendors (Oguntona & Kanye, 1995) in townships, offering various snack foods high in total energy value, may also play a large role in the feeding of the urban poor.

6.4.2 MACRONUTRIENT INTAKE

The intake of the macronutrients protein, carbohydrate and fat will be discussed.

6.4.2.1 PROTEIN INTAKE

The mean figures for total protein intake for both age groups, indicate an intake that exceeded the RDA of fifty grams per day (Earl, 2000; p. 334). These high intakes of total protein have been observed to be the international tendency (Bingham et al., 1994; Bonifacj et al., 1997; Larkin et al., 1989; Stuff et al., 1983; Romieu et al., 1997). Vorster et al. (1997) reported from South African studies that the intakes of total protein of adult Whites, Africans, Coloureds, and Indians were found to either meet, or exceed recommended intakes. In our study, the mean intake of total protein for both age groups exceeded the mean intake of 71.2 grams per day reported by Vorster et al. (1997) for urban African women. This trend of high total protein intake may be ascribed to the fact that urbanisation is accompanied by the increased intake of animal protein typical of a more Western diet (Vorster et al., 1997). Diets become more diverse with urbanisation, with more people including meat and fish, milk, eggs and cheese into their habitual diet (Drewnowski & Popkin, 1997). The free availability of cheaper cuts of red meat, offal, sausage, chicken and chicken offal, could contribute to the high intake of total protein in this study.

According to MacIntyre (1998), the ratio of plant to animal protein intake has changed dramatically in the diets of urbanised Africans, with rural African women consuming more plant proteins than their urban counterparts. This was also true in our study, where the mean plant protein intake was lower in both age groups than animal protein

intake. The consumption of cheaper vegetable proteins, including a bean-and-samp combination typical of an African diet, commercial baked beans and texturised vegetable protein, amongst others, could however have contributed to the fairly balanced intake of animal and plant proteins of subjects in this study.

6.4.2.2 CARBOHYDRATE INTAKE

The mean total carbohydrate intake of women of both age groups in this study exceeded the RDA (Tables 5.12 and 5.13). This is similar to mean intakes of carbohydrates in international studies (Bingham et al., 1994; Bonifacj et al., 1997; Larkin et al., 1989; Stuff et al., 1983; Romieu et al., 1997). In South Africa, Bourne et al. (1993) reported a considerably lower mean intake of carbohydrates (214 g/day) by urban African women in the age group 19-44 years, in a similar study, where the 24-hour recall method of dietary assessment was used. Higher mean carbohydrate intakes were however reported for Africans by Vorster et al. (1997) using a variety of assessment methods, including the FFQ, than intakes reported by Bourne et al. (1993). Notwithstanding the high mean total carbohydrate intake, a staple diet of cereals and grains (Tables 5.22 and 5.23), typical of this study group, may have beneficial health effects (Venter et al., 1990). Although the mean total carbohydrate intake of women of both age groups fell within the recommended fifty to sixty percent of the total energy intake per day, the total mean energy intake of women of both groups was too high, placing them at risk for developing chronic diseases, including obesity and type 2 diabetes mellitus.

The mean total sugar intake of women in both age groups in this study seemed to be lower than the mean intake of 94.2 gram per day reported for urban black women in South Africa (Vorster et al., 1997), and even lower than the mean total sucrose intake

reported from two overseas studies (Bingham et al., 1994; Bonifacj et al., 1997). Mean intakes were however higher than the 44.6 grams per day reported for rural black women by Vorster et al. (1997). With urbanisation, "new foods" high in sugar, become freely available (Drewnowski & Popkin, 1997), while preferences for sweetened foods are also regarded by many people as an innate human trait (Drewnowski & Popkin, 1997).

The mean intake of total dietary fibre of women in both age groups fell within the recommended twenty to thirty grams per day (Truswell, 1994), with possible beneficial effects against the development of certain chronic diseases of lifestyle (Vorster et al., 1997). Figures obtained in this study compare favourably with figures from two international studies (Bingham et al., 1994; Romieu et al., 1997), and a study on rural Zulu women in South Africa, using the 24-hour recall assessment method (De Villiers, 1988). Dietary guidelines for fibre intake were met in several other South African groups using a variety of assessment methods, including the food frequency questionnaire (Vorster et al., 1997). These findings are in contrast with literature stating that Westernisation leads to fibre-depleted carbohydrates (O'Dea, 1991; Popkin, 1994; Monteiro et al., 1995). The fact that approximately half of all the respondents in this study had been living in Mangaung for less than ten years (Appendix A), and thus perhaps still being in the process of urbanisation, might have an influence on the dietary fibre intake of these women. The consumption of freely available fruit and vegetables increases with urbanisation, leading to higher dietary fibre intakes in urban African groups (MacIntyre, 1998). From the lists of the top thirty most frequently consumed foods by mass (Tables 5.22 and 5.23), it became evident that fruit such as apples, bananas and oranges, vegetables such as spinach and cabbage, and cereals such as oats porridge are popular food choices of the African women participating in our study.

6.4.2.3 FAT INTAKE

The mean total fat intake of women in both age groups was considerably higher than the recommended intake of less than 73 grams per day, and higher than results of fat intakes obtained from several overseas studies (Bingham et al., 1994; Bonifacj et al., 1997; Larkin et al., 1989; Stuff et al., 1983; Romieu et al., 1997). In South Africa, rural blacks follow a diet much lower in fat than urban blacks (Vorster et al., 1997). The typical African diet consists of 23 percent fat (Gresse et al., 1993), while in this study, fat made out 32 and 31 percent respectively for the young and older age group, of the total energy intake. These results compare favourably with reported results of approximately thirty percent fat intake by Vorster et al. (1997), MacIntyre (1988), and Bourne et al. (1995). Saturated fat intakes of 30.8 grams and 26.7 grams per day for women in the younger and older age groups respectively, were higher than the recommended intake of less than 24 grams per day. These figures were higher than figures reported by Romieu et al. (1997), and Bourne et al. (1993), using the 24-hour recall method, but lower than figures reported by Bonifacj et al. (1997).

The high intake of saturated fats may be ascribed to the global preference for higher proportions of meat, eggs (Popkin, 1994; Monteiro et al., 1995) milk, and cheese, typical of a more Western diet (Drewnowski & Popkin, 1997), and the inclusion of brick margarine and meat drippings used in cooking. It has also been observed in this study that eggs are included in the diet of most African women.

The mean intake of mono-unsaturated fats in the study group was high for women of both age groups, comparing favourably with results found by Bonifacj et al. (1997).

Contrasting to these results, low mean intakes were reported by Romieu et al. (1997), and Bourne et al. (1993) using the 24-hour recall method. The mono-unsaturated fat intake calculated as percentage of the total energy intake, was ten percent in women in both age groups. The high intakes of these fats can be ascribed to the global availability of cheap vegetable oils used for cooking purposes, resulting in greatly increased mono-unsaturated fat consumption among low-income groups (Drewnowski & Popkin, 1997). Furthermore, mono-unsaturated fats are found in foods such as peanuts, a rich source of these fats, which is freely available from street vendors. Mono-unsaturated fats are also found in small quantities in foods such as popcorn, red meat, chicken, mayonnaise, and potato crisps, which are favourate foods in this community.

The mean poly-unsaturated fat intake for women of both age groups exceeded the recommended intake of less than 24 grams per day. These findings were in contrast with South African findings of 11 grams per day reported by Bourne et al. (1993) and international findings (21.4 grams per day) by Bonifacj et al. (1997), and Romieu et al. (1997), who reported 6 grams and 5 grams per day respectively from two FFQ.

It is important to note that the total energy intake in this group was high, indicating that even though the percentage of energy from fats was not excessive, the actual intake of fats (in gram) exceeded recommendations (Truswell, 1994).

The high mean daily cholesterol intakes observed in this study may be due to the fact that cheaper fatty red meat, eggs, offal and organ meat including liver, which are rich sources of cholesterol, are consumed on a fairly regular basis by this African group of women. It was not surprising that offal was included in the top thirty most frequently consumed foods by mass by the older group of women (Table 5.17). The results

obtained in this study however compare favourably with the results from studies by Bonifacj et al. (1997) and Romieu et al. (1997). The figures of 377.9 and 339.3 milligrams cholesterol intake per day however exceed the guideline of less than 300 milligrams per day (Truswell, 1994). According to Vorster et al. (1997) mean cholesterol intake levels in rural black women were much lower (232 milligrams per day) than levels in urban black women, which were reported as 329 milligrams per day.

6.4.3 MICRONUTRIENT INTAKE

The intake of minerals and trace elements, and water- and fat-soluble vitamins will be discussed in the following section.

6.4.3.1 MINERAL AND TRACE ELEMENT INTAKE

The intake of calcium, chromium, copper, iron, iodine, potassium, magnesium, manganese, sodium, phosphorus, selenium, and zinc of women will be discussed in the following sections.

i) CALCIUM

Despite the fact that milk was the third most frequently consumed food in the younger group of women, and the second most frequently consumed food in the older group of women, the calcium intake remained insufficient. The mean intake of calcium of women in both age groups fell below the AI of 1000 mg/day, with more than half of the respondents from both age groups taking less than 67 percent of the RDA (Tables 5.16 and 5.17). These results are consistent with results from other South African studies (Vorster et al., 1997), in which assessment methods including the FFQ were used.

Figures obtained with the 24-hour recall method (Bourne et al., 1993; Vorster et al.,1997) were however much lower than the results in this study, which may point at underreporting, typical of the 24-hour recall method. It is therefore evident that many South Africans consume milk, but not in sufficient quantities. If milk is the only dairy product used in the diet, one has to include 3-4 cups per day to meet the 1000 mg calcium per day recommended for women 19-50 years of age. A calcium depleted diet may further be ascribed to low milk intakes reported for Africans, caused by cultural habits and taboos regarding milk consumption, lactose intolerance, which is high in Africans, as well as the high cost of dairy products (Vorster et al., 1997). Furthermore, the general preference for non-dairy coffee creamers, which do not need refrigerated storage, could have an influence on calcium intakes.

Osteoporosis is currently believed not to be a public health problem in black South Africans compared with their White counterparts. Results from the THUSA study however showed that postmenopausal black women were osteopenic, with an increased risk of developing osteoporosis and fractures. With further urbanization and the nutrition transition, osteoporosis could therefore be expected to become an increasing health problem (Vorster, 2000).

ii) CHROMIUM

Mean intakes of chromium were almost double the AI of 25 μg in both age groups. Only 10.8 and 11.5 percent of women from the young and older age group respectively, took less than 67 percent of the RDA. These high intakes may be the result of a diet high in

organ meats, including liver, which is a relatively cheap source of this mineral, and leafy vegetables such as spinach and cabbage, which are both popular food choices amongst these African women.

iii) COPPER

The RDA of 9 milligrams copper per day was not met by women in either of the two age groups in this study. These findings compare favourably with those of Bourne et al. (1993), using the 24-hour recall assessment method. Marine sources of this mineral, including oysters and shellfish, are expensive, and do not form part of the diet of these Africans. The low mean intakes of this mineral should be a matter of concern, as copper promotes the absorption of iron, which was inadequately taken in this study. Zinc on the other hand, is an antagonist to copper, as it reduces the absorption of this mineral (Stanfield, 1997, p. 108). Zinc intakes in this study were higher than the RDA, which could further have an influence on the biochemical profile of these women.

iv) IRON

The total mean iron intakes of subjects reflect a pattern of low intakes of this mineral. Of particular concern, is the relatively high proportion (49.1 and 53.5 percent respectively) of the women in both age groups taking less than the RDA of 18 mg/day (Tables 5.16 and 5.17). These figures compare favourably with results reported by Bourne et al. (1993) and Vorster et al. (1997), with the 24-hour recall assessment method, and Vorster et al. (1997), using methods including the FFQ. The iron requirements of pre-menopausal women are higher than those of men, making iron deficiency a serious problem amongst women. Iron is known for its protective role against iron deficiency

anemia (MacPhail, 1998, p. 145). The inclusion of iron absorption inhibitors such as phytate, polyphenols present in unrefined cereals, vegetables including spinach, tea and coffee may play a role in iron deficiency, while ascorbic acid enhances iron absorption (MacPhail, 1998, p. 141). Lean meat, an expensive but rich source of iron, should be promoted to form part of the diet. An iron fortification or supplementation programme should be targeted at iron deficient women, especially of childbearing age.

v) IODINE

The total mean intake of iodine was markedly low in both subject groups, with 94.6 and 96.8 percent in the younger and older age groups respectively taking less than 67 percent of the RDA. These low mean intakes of iodine may be ascribed to the fact that respondents were not queried on the use of table salt, and the amount of salt added during food preparation, when the FFQ was administered. This is considered a limitation, as the table salt available in South Africa is iodised. Certain foods, including cabbage, which is favoured by African people, contain substances that interfere with the absorption of iodine. Although no biochemical data on micro-nutrient status was obtained in this study, the consumption of cabbage could have a further negative influence on the iodine profile of these women. Fish is an acceptable and well-liked food under these African women, but accessibility and price are major constraints for regular consumption. Consumption of the main sources of this mineral, namely marine fish and iodised salt on a more regular basis, should thus be promoted amongst African women.

vi) POTASSIUM

The high mean intakes of potassium observed in women of both age groups, are

consistent with results reported by Vorster et al. (1997). Bourne et al. (1993), using the 24-hour recall method, however reported intakes lower than the RDA of 2000 mg/day.

Bananas, a rich source of potassium, were listed under the top thirty most frequently consumed foods, and could therefore have contributed to total potassium intakes of the subjects.

vii) MAGNESIUM

Magnesium intakes are related to the inclusion of fruit, vegetables and legumes in the diet. In this study, women from the younger age group showed magnesium intakes lower than the RDA, while women from the older age group, showed intakes higher than the RDA. A relatively small percentage of the total sample consumed less than 67 percent of the RDA for magnesium. Data from other studies obtained by assessment methods including the FFQ, showed adequate intakes of this mineral. Therefore there may be magnesium deficiencies in some adult groups, which could be rectified by the inclusion of more fruit, vegetables and legumes in the diet (Vorster et al., 1997).

viii) MANGANESE

Mean intakes of manganese for women of both age groups met the RDA of 1800 μg per day. The consumption of peanuts, available from street vendors, legumes, coffee and grains on a regular basis, may have played a role in the manganese intake of women that participated in this study.

ix) SODIUM

Mean intakes of sodium for women of both age groups were low, if compared with the RDA of 3000 milligrams per day (Tables 5.16 and 5.17). These results were consistent with those reported by Bourne et al. (1993), with the 24-hour recall method. Vorster et al. (1997) however reported sodium intakes that exceeded the estimated safe and adequate daily dietary intakes. One of the limitations of the FFQ in our study was that questions on the use and addition of table salt during food preparation were not included. Subjects could therefore have included more sodium than the figures that were reported.

High sodium intakes are associated with hypertension, which commonly appear under African women (Opie, 1995). In this study group, the adequate intake of sodium should therefore be maintained, by either excluding, or limiting processed foods and savoury snack foods high in sodium.

x) PHOSPHORUS

The mean phosphorus intakes of women in both groups were adequate. These results were consistent with results reported by Vorster et al. (1997) and Bourne et al. (1993), using the 24-hour recall method. The fairly regular inclusion of poultry, canned fish, eggs, peanuts, carbonated drinks, fruit and vegetables could have contributed to the sufficient intake of this mineral. A persistently elevated phosphorus concentration contributes to increased bone turnover that potentially can result in a reduction of bone mass and density. If this condition is chronic, it could contribute to fragility fractures

because of excessive resorption and thinning of trabecular plates at bone sites throughout the skeleton (Anderson, 2000 pp. 118-119).

xi) SELENIUM

The mean selenium intake of women in both age groups were slightly lower than the RDA, and about half of the total sample took less than 67 percent of the RDA. The regular inclusion of meat and eggs, which are the main sources of this mineral (Stanfield, 1997, p. 109), on a regular basis, should aid in correcting this deficient intake.

xii) ZINC

The mean intake of zinc of women of both the younger and older age group was sufficient. In contrast to the findings in this study, Bourne et al. (1993), reported intakes lower than the RDA of 8 mg/day used in our study, with the 24-hour recall method. Vorster et al. (1997) compared the zinc intake of urban African women with an RDA of 12 milligram, which was not met in their study. It was thus reported that zinc may be a mineral that needs attention in the diet of some South Africans.

6.4.3.2 VITAMINS

The intake of water-soluble vitamins thiamin, riboflavin, niacin, pantothenic acid, vitamin B6, biotin, folate, vitamin B12, and vitamin C, will be discussed in the following sections.

i) WATER-SOUBLE VITAMINS

Discussion of results of the water-soluble vitamins follow.

a) THIAMIN, RIBOFLAVIN, NIACIN, PANTOTHENIC ACID, VITAMIN B6, AND BIOTIN

The mean intakes of thiamin, riboflavin, niacin, pantothenic acid, vitamin B6, and biotin seemed to be satisfactory (Tables 5.20 and 5.21). A fairly large percentage of the total sample however took in less than 67 percent of the RDA for vitamin B6 and biotin. The mean results for thiamin, riboflavin and niacin compare well with the mean results of South African studies in which the Food Frequency Questionnaire was used (Vorster et al., 1997). Bourne et al. (1993), however reported intakes lower than the RDA's for thiamin, riboflavin, and niacin with the 24-hour recall method.

According to Vorster et al. (1997), thiamin intake is not a problem in South Africa. The results in our study also indicated adequate intakes of this nutrient.

One of the favoured foods included by Africans in their diet is sour milk, which is a rich source of riboflavin. Although sour milk *per se* did not appear on the lists of the thirty most frequently consumed foods by the women in our study, milk was listed as the second and third most popular foods consumed by mass by the older and younger women respectively in this study, which could explain why riboflavin requirements were met.

Niacin is known for its activity as pellagra-preventing vitamin. The niacin in cereals appears in a complex form, which humans cannot absorb, making it biologically unavailable to the body. According to Truswell & Milne (1998, p. 203), people eating a diet predominantly of maize, with few other foods, might develop a niacin deficiency. Maize-meal has however been fortified with niacin in South Africa for many years (Walker et al., 1983).

Vitamin B6 occurs in a wide range of unprocessed or lightly processed foods including meat, whole grain products, vegetables and nuts (Truswell & Milne, 1998, p. 208), making this study group who eat a fairly diverse diet, less vulnerable to a deficiency of this vitamin. The Greek word "pantothen" means "from everywhere", stating that this vitamin is widely distributed in several foods from plant and animal origin, thus increasing the chances of including this vitamin in the diet.

b) FOLATE

Folate plays a vital role in preventing megaloblastic anemia, and in protecting the fetus against neural tube defects (Truswell & Milne, 1998, p. 211). The low mean folate intake, particularly of the younger women, is therefore a matter of concern. The insufficient consumption of folate seems to be a problem among Whites (mean daily intake 274 μg), urban and rural Africans (mean daily intakes 229 μg and 168 μg respectively), and Coloureds (mean daily intake 164 μg) in South Africa (Vorster et al., 1997). Special attention should be focused on the inclusion of adequate folate-rich foods by these young women of child-bearing age. This nutrient occurs in leafy vegetables including spinach and cabbage, but also in other foods such as organ meat,

bananas, eggs, fresh fruit and vegetables (Truswell & Milne, 1998, p. 212), which are relatively cheap, freely available, and favoured sources of folate. The regular inclusion of these food sources, together with the application of short cooking periods for leafy vegetables, may help to rectify this problem.

c) VITAMIN B12

Vitamin B12 is needed by the body in very small quantitites. The mean intake of vitamin B12 was not only met by women of both age groups in this study, but also in other South African studies (Vorster et al., 1997; Bourne et al., 1993). The inclusion of animal sources in the diet eliminates the possibility of a vitamin B12 deficiency, placing only the poorest of the poor at risk. Furthermore, body stores of this vitamin are sufficient to last for three to six years (Truswell & Milne, 1998, p. 215).

d) VITAMIN C

The role of vitamin C as an anti-oxidant has been intensely studied in relation to disease prevention, including certain cancers (Stanfield, 1997, p. 95). The intake of the recommended dietary allowance of 75 mg is therefore of utmost importance. In this study, the mean intake of vitamin C for women in the age group 25-34 years was sufficient, while in the age group 35-44 years, the mean intake failed to meet the RDA. Furthermore, 46,2 percent of women from the younger group, and 53.9 percent of women in the older group took in less than 67 percent of the RDA. Bourne et al. (1993), also reported intakes of vitamin C lower than the RDA with the 24-hour recall method. Intakes below 75 mg/day, measured with the food frequency questionnaire, were also reported for urban black women by Vorster et al. (1997). Increasing the intake of this

vitamin will lead to improved iron absorption. Cigarette smoking, which was a common occurance under the respondents in this study (not reported here), can have a further negative effect on lowering plasma concentrations of vitamin C (Skeaff, 1998, p. 221), emphasising the importance of increasing the intake of fresh fruit and vegetables rich in vitamin C.

ii) FAT-SOLUBLE VITAMINS

The intake of the fat-soluble vitamins A, D, E, and K of the women will be discussed in the following section.

a) VITAMIN A

Although the mean intake of vitamin A seemed to be adequate for women of both age groups, 30.1 percent from the women in the younger age group, and 25.4 percent of the women in the older age group took in less than 67 percent of the RDA (Tables 5.18 and 5.19). The mean intakes reported from other South African studies using the food frequency questionnaire showed adequate intakes, while intakes below the RDA were reported with the 24-hour recall method.

The population group currently at highest risk for vitamin A deficiency is children beyond the weaning age. Pregnant and lactating women are also affected, particularly women of lower to middle social class (West, 1998, p.187), such as those in this study.

In Western countries, the predominant source of vitamin A activity is preformed vitamin A, present in products such as milk, butter, cheese, egg yolk, liver and some fatty fish.

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In Western countries, the predominant source of vitamin A activity is preformed vitamin A, present in products such as milk, butter, cheese, egg yolk, liver and some fatty fish.

Vitamin A can also be derived from provitamin A compounds like β-carotene produced by plants. Main sources of provitamin A are dark green leafy vegetables such as spinach, and some yellow- and orange coloured fruits and vegetables. Fruits such as mangos and papaya, yellow/orange varieties of vegetables such as pumpkin, and sweet potato, milk and dairy products, eggs and liver can all contribute significantly to vitamin A status. Unfortunately, such foods are not always available or expensive, making it necessary to turn to fortification or enrichment of certain foods (West, 1998, p. 191-192).

b) VITAMIN D

The mean intake of vitamin D for women in both age groups was slightly higher than the AI. A large percentage of women from both age groups (29.4 percent from the younger women, and 36.9 percent from the older women) however took in less than 67 percent of the AI. Results of the mean intake are in contrast to other findings, in which intakes lower than the AI were reported with both the 24-hour recall method and the food frequency questionnaire (Vorster et al., 1997).

The regular intake of fish liver oils, fatty fish, such as sardines, and fortified margarines, eggs, beef and lamb liver, could aid in rectifying deficiencies. An adequate calcium intake can further assist in the absorption of vitamin D (Truswell, 1998, p. 238-239).

In South Africa with its fair amount of sunshine through the year, enough vitamin D is made in the skin by ultra-violet irradiation (Truswell, 1998). When people however live at high altitudes, are covered with clothes, spend nearly all their time indoors, and the sky is polluted with smoke, there is however insufficient ultra-violet exposure to make

enough vitamin D in the skin. Dietary intake is then required so that cholecalciferol in foods and ergocalciferol in fortified foods assume the role of a vitamin (Truswell, 1998).

c) VITAMIN E

Although mean intakes of Vitamin E were sufficient for women of both age groups, more than 25 percent of women from both age groups took in less than 67 percent of the RDA. Bonifacj et al. (1997) determined vitamin E intake of a sample of healthy male and female in the French Mediterranean region. A mean intake of 20.2 mg/day was reported with the FFQ method of dietary assessment, which was slightly higher than the mean intakes of 18.1 and 16.4 mg/day respectively for the younger and older groups of women in our study.

Vitamin E is a powerful antioxidant which plays an essential role in protecting cell membranes and plasma lipoproteins from free radical damage (Skeaff, 1998, p. 226). Foods high in fat, particularly polyunsaturated fat and wheat germ oil are rich sources of this vitamin. Wheat germ oil is unfortunately an expensive commodity, that does not form part of the diet of this study group. The regular consumption of peanuts (Skeaff, 1998, p. 230-231) which are freely available, and a fairly cheap source of vitamin E, should be promoted.

d) VITAMIN K

The mean intakes of vitamin K were high, with women from both age groups taking in more than double the AI. These high figures may be attributed to the inclusion of dark

green leaves such as spinach and cabbage. Beef liver, some vegetable oils, apples and cheese also contain Vitamin K (Truswell, 1998, p. 242-243).

6.4.4 THIRTY MOST FREQUENTLY CONSUMED FOODS

Although the food trends of the studied group of women tended to move towards a more Western style, traditional foods have not been totally eliminated (Tables 5.22 and 5.23). A disturbing finding is that 25 to thirty percent of these foods were in the form of typical Western beverages. It is thus clear that urbanisation in this study group has led to high consumption rates of carbonated drinks, cold drinks, coffee, tea, and commercial beer. The harmful effects of alcohol use and abuse can have detrimental effects on adult health, teratogenic effects on the unborn, and negative social and economic effects (Van Heerden & Parry, 2001), and should therefore be discouraged.

Tea and milk seemed to be favourite foods for women of both age groups. These findings were in keeping with results from the Transition and Health during Urbanisation of South Africans (THUSA) study (MacIntyre, 1998), in which tea and milk were also amongst the three foods consumed in the largest amounts per person per day.

Evidence from the results obtained by the list of the thirty foods most frequently consumed by mass, was that a cereal-based diet with several health benefits, is still followed by these women. According to MacIntyre (1998), maize products were also consumed in larger amounts than milk in the THUSA study. Unfortunately, some of these foods, such as white rice, white bread, vetkoek, and maize porridge are in the refined and processed forms, depleting them of valuable micronutrients. It should thus

be recommended to choose unrefined or minimally processed cereals and grains where possible, and to concentrate on fortified cereals and grains when available. The pending fortification of maize meal and bread flour with micronutrients should help to increase the contribution of these foods to micronutrient intakes. The inclusion of the traditional samp-and-bean combination in the diet should be further encouraged as a substitute for costly animal-derived and fatty foods (Vorster & Nell, 2001).

A surprising fact was that red meat did not fall within the thirty most frequently foods consumed by these women. Chicken was however listed by women of both age groups as number 28 on the list of foods most frequently consumed. Furthermore, offal, which is a rich source of cholesterol, was included in the list of popular foods of the older group of women. In the THUSA study, red meat was among the top ten foods consumed in the largest amounts per person per day, except for subjects living on farms (MacIntyre, 1998). In our study group, it was found with the FFQ that red meat, and other animal foods formed a regular part of the diet of most respondents, but that portion sizes are small. Cost could perhaps be seen as the main constraint that has a limiting effect on meat intake.

Although fruit seemed to be a popular food choice of both groups of women, the inclusion of plenty of fruit and vegetables should receive higher priority, in order to meet the minimum daily recommendation of five portions or 400 g/day (Hunt et al., 1995). According to literature, fruit and vegetables are eaten by urban Africans, but in small amounts, usually one small portion per day (Vorster et al., 1997). Affordability and availability of fruit and vegetables may perhaps be considered as possible barriers in fruit and vegetable consumption. Vegetables and fruit are however today freely available at reasonably low prices when in season, from street vendors in the African

residential areas. Money spent on fruit and vegetables, rather than on alcoholic drinks, should be propagated as a better investment in general health.

The mean total fat intake of women in both age groups was higher than the recommended intake of less than thirty percent of the total daily energy intake (Tables 5.14 and 5.15). These high intakes of fat could partially be explained by the intake of fried foods such as french fries and vetkoek, which were favourite food choices by women of both age groups.

6.5 BIOCHEMICAL PARAMETERS

The biochemical parameters fasting TG, fasting total cholesterol, fasting serum albumin, fasting serum glucose, and serum insulin will be discussed.

6.5.1 FASTING TG

Although most of the women of the two age groups had normal fasting TG levels (Table 5.26), the increased levels in the older women should be a matter of concern. Increased TG levels are caused by factors including diet, alcohol, obesity, and untreated diabetes mellitus. Weight loss, following a low-saturated fat or low-cholesterol diet, increased physical activity, smoking cessation, management of diabetes if present, and restricted alcohol use, should aid in lowering high TG levels (Krummel, 2000, p. 573).

6.5.2 FASTING TOTAL CHOLESTEROL

Although a large percentage of women showed fasting cholesterol levels falling within the normal range, a high percentage of older women fell in the moderate risk group (Table 5.27). Total cholesterol levels in the QwaQwa-Mangaung study indicated higher cholesterol levels in Mangaung than in QwaQwa. The large number of subjects in the moderate risk group was a disturbing factor in the Qwa-Qwa-Mangaung study (Mollentze et al., 1995), as is the case in this study. An outstanding feature in our study was the high percentage of women from the older age group with high total cholesterol levels, while in the QwaQwa-Mangaung study, the reverse was found (Mollentze et al., 1995). Such raised cholesterol levels are due mainly to a diet high in saturated fat (O'Dea, 1991), and animal products (Vorster et al., 1997), typical of urbanisation and a Western eating style.

6.5.3 FASTING SERUM ALBUMIN

Fasting serum albumin levels of the women fell within the normal range of 34-48 g/l (Roche Diagnostics, catalogue no. 1970569). The median results of 41.3 and 41.5 g/l obtained for the younger and older age groups respectively, compared favourably with the mean of 40.4 reported for urban African women in the age group 31 to fifty (Watters et al., 1985).

6.5.4 FASTING SERUM GLUCOSE

For most women in the two age groups, fasting serum glucose levels fell within the normal range of 3.05-6.38 mmol/l (Table 5.29). These results are in keeping with

findings of a South African study performed by Van der Merwe et al. (1999), in which normal fasting blood glucose levels (4.3 mmol/l) were reported for healthy female control subjects with normal weight. Figures of 4.7 mmol/l were revealed for women in the North West Province, by Van Jaarsveld (1989). Slightly higher, but still within the normal range, fasting plasma glucose levels (5.4 mmol/l) were reported for South African Indians (control group with normal weight) by Motala & Omar (1993). The fact that the majority of subjects in our study had a gynoid fat distribution, could have contributed to the relatively low serum glucose levels.

Raised blood glucose levels (glucose intolerance) are associated with risk for developing diabetes mellitus. It is well-known that in some population groups, there have been dramatic increases in the prevalence of type 2 diabetes associated either with migration or with a rapid change from a traditional lifestyle to an increased consumption of energy-dense foods high in fat and sugars, and reduced levels of physical activity. From the women in the younger group, 10.5 percent however had blood glucose levels above normal, while from the older group only 4.2 percent had blood glucose levels above normal. The fact that approximately half of all the respondents in this study had been living in Mangaung for less than ten years, indicates that diseases commonly associated with urbanisation could have had an influence on the glucose profiles of these women.

6.5.5 FASTING SERUM INSULIN

Glucose is the major physiological regulator of insulin secretion, and the pancreas is sensitive to changes in glucose at physiological concentrations. In individuals with normal glucose tolerance, fasting plasma glucose levels remain constant from day to day. This is due to an intensive coordination between hepatic glucose production and

peripheral tissue glucose uptake. Downward regulation of plasma glucose entirely depends on circulating plasma insulin, which facilitates the uptake of glucose by the peripheral tissues. Impaired glucose tolerance characterised by fasting hyperglycaemia, is largely due to increased glucagon secretion and decreased insulin production by the β cells, but is partly due to impaired hepatic insulin sensitivity (Makuyana et al., 1999).

Associations between BMI and insulin sensitivity, WHR and insulin sensitivity, and TG levels and insulin sensitivity will be discussed in sections 6.6.3, 6.6.4 and 6.6.5 respectively.

6.6 ASSOCIATIONS

Associations between fasting glucose levels and waist circumference, BMI and TG, BMI and insulin sensitivity, WHR and insulin sensitivity, and TG and insulin sensitivity will be discussed.

6.6.1 ASSOCIATION BETWEEN FASTING GLUCOSE AND WAIST CIRCUMFERENCE OF WOMEN

The use of waist circumference has recently been suggested to be a better indicator of blood pressure and fasting blood glucose than BMI and waist-to-hip ratio (Okusun et al., 1998). A waist measurement above 88 cm in women, is considered to place these individuals at higher risk for developing chronic diseases (James, 2001). In our study however, no significant association between waist circumference and elevated glucose levels were found (Table 5.31). The small percentage of women with elevated glucose levels makes statistical analysis of data difficult.

6.6.2 ASSOCIATION BETWEEN BMI AND TG

One of the factors that increases TG levels is obesity (Krummel, 2000, p. 573). Although a high rate of obesity was observed in women of both age groups in our study, no association was found between TG levels and BMI (Table 5.32). In contrast to the results in our study, Donahue et al (1988) reported a positive association between BMI and TG levels in white young males and females. The results obtained in our study may be partly ascribed to the fact that lipid profiles of black subjects were found to be less atherogenic than those of white, Indian, and Coloureds subjects (Crowther & van der Merwe, 2000).

6.6.3 ASSOCIATION BETWEEN BMI AND INSULIN SENSITIVITY

In the African population, obesity is characterized by a decrease in insulin sensitivity and lower pancreatic β cell function, which explains the increasing prevalence of type 2 diabetes mellitus in this ethnic group. Possible environmental factors involved in the pathogenesis of insulin resistance include dietary intake, with obesity resulting in increased insulin resistance, as described by Crowther and Van der Merwe (2001). Among individuals already at increased risk for lower insulin sensitivity due to obesity and a sedentary lifestyle, high intake of dietary fats may negatively influence insulin sensitivity (Mayer-Davis et al., 1997).

The relationship between high BMI and insulin sensitivity was confirmed in our study, in which the groups (young and older women) with the lowest insulin sensitivity, also had the highest mean BMI (27.6 kg/m^2), while insulin sensitivity improved as BMI decreased

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The relationship between high BMI and insulin sensitivity was confirmed in our study, in which the groups (young and older women) with the lowest insulin sensitivity, also had the highest mean BMI (27.6 kg/m^2), while insulin sensitivity improved as BMI decreased

(Tables 5.33 and 5.34). A reduction in BMI *per se* could therefore have beneficial effects on the health of these African women, regardless of fat distribution.

6.6.4 ASSOCIATION BETWEEN WHR AND INSULIN SENSITIVITY

Many researchers have suggested that WHR circumference, a significant predictor of plasma TG, glucose and insulin concentrations, correlates positively with an *in vivo* index of insulin resistance (Kissebah et al., 1982; Kalkhoff et al., 1983; Evans et al., 1984a). When the medians of WHR were compared between all insulin sensitivity quartiles by 95 percent non-parametric CI for the median difference in our study, a significant difference was only found in the insulin sensitivity of groups 1 and 4 of the older group of women. In the younger group of women, WHR was not associated with insulin sensitivity.

6.6.5 ASSOCIATION BETWEEN TG LEVELS AND INSULIN SENSITIVITY

Insulin is the major determinant and stimulant of lipoprotein lipase, an enzyme system responsible for the peripheral catabolism of triglyceride-rich lipoproteins. It is thus likely that the enhancement of insulin sensitivity would lead to a more efficient lipolytic system with a consequent decrease in the TG concentration of the individual (Donahue et al., 1988). Postprandial TG concentrations are higher in white than African obese South Africans, while insulin resistance is higher in African than white obese women (Crowther & Van der Merwe, 2000).

In a research study by Donahue et al (1988), an inverse relation between TG, insulin sensitivity, and physical activity was reported for men, but not for women participating in the study.

When the medians of TG in our study were compared between all insulin sensitivity quartiles by 95 percent non-parametric CI for the median difference, significant differences were found in the insulin sensitivity of groups 1 and 3, and groups 1 and 4 of the younger group of women, and groups 1 and 2, and groups 1 and 4 of the older group of women (Tables 5.37 and 5.38), indicating that as insulin sensitivity decreases, TG levels tend to increase.

An increase in physical activity can have beneficial effects on the TG profile and insulin sensitivity of the women who participated in our study.

6.7 SUMMARY

The prevalence of overweight, obesity and a high fat percentage in this population, can be ascribed to a diet with a high energy and fat content. Although not reported here, levels of physical activity was extremely low.

The transition to a more westernised diet, became evident in the macronutrient intake of women in this study. The consumption of an energy-dense and diverse diet, typical of this transition, contributed to the high mean total energy and protein intakes. Notwithstanding the high mean total carbohydrate intakes, a staple diet of cereals and grains may have certain beneficial health effects for these women. The adequate intake

of dietary fibre by the population group in this study, was in contrast with international literature stating that westernisation leads to the increased consumption of fibre-depleted carbohydrates. The consumption of freely available fruit and vegetables from street vendors could have played a major role in the dietary fibre intake of these women. Furthermore, the fact that most women who participated in the study have been residing in an urban area for a relatively short period, and perhaps not been completely westernised, could have a further influence on the fibre intake. The high total fat intake observed in this study, may be ascribed to the increasing preference for cheaper red meat, offal, eggs, full-cream milk, cheese, brick margarine, and meat drippings used in food preparation. The inclusion of these foods in the diet could explain the high total cholesterol intake reported in this study.

Although milk ranked high on the list of the thirty most frequently consumed foods by mass, calcium intake remained insufficient. The inclusion of organ meats and leafy vegetables could have contributed to high mean intakes reported for chromium. The low mean intakes of copper could be ascribed to the cost factor associated with marine food sources of this mineral, and the fact that foods such as oysters and shellfish do not form part of the diet of these African women. The iron-deficient diet was a serious problem amongst these pre-menopausal women, emphasising the urgency of an iron fortification or supplementation programme. The low and adequate mean intakes observed for iodine and sodium respectively, could be ascribed to the fact that although respondents were queried on the use of flavoured salt and stocks during food preparation, no questions on the addition and use of iodized salt were asked. The low mean intakes reported for magnesium, could be rectified by a diet rich in fruit, vegetables and legumes, which are all accessible to these women. Unlike the diet of many South Africans, the mean zinc intake of women of both age groups was adequate.

Although the total mean intakes of thiamin, ribloflavin, niacin, pantothenic acid, vitamin B6 and biotin were adequate, a fairly large percentage of the sample consumed less than 67 percent of the RDA for vitamin B6 and biotin. The low total mean intakes of folate should be a matter of concern, particularly in the younger women of child-bearing age. The regular inclusion of food sources rich in this mineral should be promoted under women of both age groups. The low mean intakes reported for vitamin C, emphasise the importance of an increase in the consumption of fruit and vegetables.

The fairly large percentage of women from each age group consuming less than 67 percent of the RDA for vitamin A, D and E, needs to be addressed.

The trend towards a more westernised eating pattern became evident in the list of thirty most frequently consumed foods by mass, with the inclusion of western beverages, and dried foods. Although a cereal-based diet was still the norm, many of these foods were unfortunately consumed in the refined form.

The increased total cholesterol and TG levels of the older women place these women at risk for developing some chronic diseases. Fasting serum albumin and fasting serum glucose levels of this population group compared favourably with results from some South African studies.

Although the use of waist circumference has recently be suggested to be a better indication of blood pressure and fasting blood glucose than BMI and WHR, no significant association between waist circumference and elevated blood glucose levels were found in this study.

The fact that lipid profiles of black subjects were found to be less atherogenic than those of other population groups, might have contributed to the fact that no association was found between TG and BMI.

Although the prevalence of type 2 diabetes in this population is low, the association found between insulin sensitivity and BMI indicates that a large proportion of women are at risk of developing hyperinsulinaemia as their BMI increases, which in turn could lead to an increased risk for type 2 diabetes.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

In this study of a community undergoing rapid epidemiological and demographic transition, high rates of obesity and insulin resistance were identified. The effects of the nutrition transition are also reflected in the current diet of these subjects, with some nutrients consumed in excess, and others in inadequate quantities.

In the African population, obesity *per se* is characterised by higher insulin resistance and lower pancreatic β cell function (Crowther & van der Merwe, 2001), which explains the increasing prevalence of type 2 diabetes mellitus in this ethnic group.

7.2 CONCLUSIONS

The following conclusions evolved from the study:

7.2.1 ANTHROPOMETRY

- The prevalence of overweight and obesity in the studied group of women was an outstanding anthropometric feature.
- In this study, most women in both age groups had a waist-hip-ratio smaller than 0.80 centimeters, indicating a gynoid fat distribution.

- A matter that needs to be addressed urgently, is the total number of women who demonstrated extremely high fat percentages. Regardless of weight, almost all the subjects had a fat percentage higher than the recommended twenty to 25 percent.

7.2.2 DIETARY INTAKE

- The mean energy intake of women in both age groups was high.
- The mean figures for total protein intake for both age groups, indicate an intake that exceeded the RDA of fifty grams per day.
- The mean total carbohydrate intake of women of both age groups in this study exceeded the RDA.
- The mean total fat intake of women in both age groups was considerably higher than the recommended intake of less than 73 grams per day.
- Calcium intake was insufficient.
- The RDA of 9 milligrams copper per day was not met by women in either of the two age groups in this study.
- The total mean iron intakes of subjects reflect a pattern of low intakes of this mineral.
- High mean intakes of potassium were observed in women of both age groups.
- In this study, women from the younger age group showed magnesium intakes lower than the RDA, while women from the older age group, showed intakes higher than the RDA.
- Mean intakes of manganese for women of both age groups met the RDA of 1800 μg per day.
- The mean phosphorus intakes of women in both groups were adequate.

- The mean selenium intake of women in both age groups were slightly lower than the RDA, and about half of the total sample took less than 67 percent of the RDA.
- The mean intake of zinc of women of both the younger and older age group was sufficient.
- The mean intakes of thiamin, riboflavin, niacin, pantothenic acid, vitamin B6, and biotin seemed to be satisfactory. A fairly large percentage of the total sample however took in less than 67 percent of the RDA for vitamin B6 and biotin.
- The low mean folate intake, particularly of the younger women, is a matter of concern.
- The mean intake of vitamin B12 was met by women of both age groups in this study.
- The mean intake of vitamin C for women in the age group 25-34 years was sufficient, while in the age group 35-44 years, the mean intake failed to meet the RDA.
- Although the mean intake of vitamin A seemed to be adequate for women of both age groups, 30.1 percent from the women in the younger age group, and 25.4 percent of the women in the older age group took in less than 67 percent of the RDA.
- The mean intake of vitamin D for women in both age groups was slightly higher than the AI.
- Although mean intakes of Vitamin E were sufficient for women of both age groups, more than 25 percent of women from both age groups took in less than 67 percent of the RDA.
- The mean intakes of vitamin K were high.
- Although the food trends of the studied group of women tended to move towards a more Western style, traditional foods have not been totally eliminated. It is thus clear that urbanisation in this study group has led to high consumption rates of carbonated drinks, cold drinks, coffee, tea, and commercial beer. A cereal-based diet with

several health benefits, is still followed by these women. Unfortunately, some of these foods, such as white rice, white bread, vetkoek, and maize porridge are in the refined and processed forms, depleting them of valuable micronutrients. It should thus be recommended to choose unrefined or minimally processed cereals and grains where possible, and to concentrate on fortified cereals and grains when available. The pending fortification of maize meal and bread flour with micronutrients should help to increase the contribution of these foods to micronutrient intakes. The inclusion of the traditional samp-and-bean combination in the diet should be further encouraged as a substitute for costly animal-derived and fatty foods. It was found with the FFQ that red meat and other animal foods formed a regular part of the diet of most respondents, but that portion sizes are small. The inclusion of plenty of fruit and vegetables should receive higher priority.

The mean total fat intake of women in both age groups was high. These high intakes of fat could partially be explained by the intake of fried foods such as french fries and vetkoek.

7.2.3 BIOCHEMICAL PARAMETERS

- For most women in the two age groups, fasting serum glucose levels fell within the normal range of 3.05-6.38 mmol/l.

7.2.4 ASSOCIATIONS

- No significant association between waist circumference and elevated glucose levels was found.

- Although a high rate of obesity was observed in women of both age groups in our study, no association was found between triglyceride levels and BMI.
- The relationship between high BMI and insulin sensitivity was confirmed in our study. As BMI increased, insulin sensitivity decreased. This indicates that this population is at risk of developing type 2 diabetes mellitus. A reduction in BMI *per se* could therefore have beneficial effects on the health of these African women, regardless of fat distribution.
- A significant difference was found in the insulin sensitivity of the older group of women as WHR increased. In the younger group of women WHR was not associated with insulin sensitivity.

- As insulin sensitivity decreases, triglyceride levels tend to increase.

7.3 RECOMMENDATIONS

Both obesity and type 2 diabetes are common consequences of changing lifestyles (increased sedentary lifestyles and increased energy density of diets), and are preventable through life-style modification on a population level, but this requires a comprehensive, community-based, integrated, multidisciplinary and multi-sectorial strategy. There is thus a need for the development of local plans for adequate prevention and management of obesity and type 2 diabetes (Seidell, 1999). Dietary modification aimed at the consumption of a more prudent diet, together with an increase in physical activity, may therefore be the optimum way of reducing not only obesity, but also its related diseases. This brings about a great challenge to all those associated with the general health of the people of this community.

Intervening strategies for primary, secondary and tertiary prevention and management of obesity and type 2 diabetes mellitus have however not been developed or implemented, thus pointing toward the great urgency for a coherent and multifaceted strategy in this regard. Before the world's medical systems are swamped by an epidemic of Western diseases of lifestyle, preventive action must be taken (Popkin & Doake, 1998). The success of a community-based lifestyle intervention programme is however dependent upon its acceptability, content, mode of delivery, sustainability, and the degree to which the community adopts it (Levitt et al., 1999).

The rates of obesity and insulin resistance in this study group need to be addressed by means of a community-based intervention programme, as the increase in morbidity and mortality due to these complications places a heavy financial load on health services (Musaiger, 1992). A strategy focusing on preventing further obesity and insulin resistance in this subgroup at risk for type 2 diabetes, and treating the already obese, should therefore be implemented.

The major intervention that is being proposed for the prevention of these disorders, should focus on the controllable, or modifiable risk factors (Levitt et al., 1999). According to Green (1984), the responsibility of public health should now focus more on the "hard to reach", who are typically disadvantaged in economic or status terms, and are more suspicious of organizations and agencies trying to help them. Improving the educational status of African girls and women (Kalk, 2001) should therefore receive high priority.

Obesity should now be accorded the seriousness it deserves (Ravussin, 2000b).

Whereas current strategies for the reduction of obesity have been aimed at treatment of the individual, a paradigm shift is now needed away from the traditional view of obesity as a personal disorder, to a population-based approach (Egger & Swinburn, 1997).

Education to increase the awareness of the health consequences of obesity (Kalk, 2001), including insulin resistance that can lead to the later onset of type 2 diabetes, should be introduced in this urban African community. Strategies for weight control should further be introduced as public health policy. According to Prentice (2000a), the design and implementation of these health interventions is a daunting challenge in countries where obesity is often culturally acceptable or even desirable.

The external environment is a modifiable risk factor for control of chronic diseases of lifestyle. Environmental factors associated with these diseases include aspects such as low levels of physical activity, accompanied by the intake of excessive kilojoules. An alteration in lifestyle, including altering attitudes towards food, weight loss, and reduced intake of dietary fat (Knowler et al., 1995), should therefore be advocated amongst this population group. From a nutritional viewpoint, nutrition education regarding food choices and meal patterns, as well as kilojoule restriction to promote weight loss should receive attention. The most likely therapy for obesity may therefore target pathways of regulating food intake (Ravussin, 2000a). People eat the foods that are supplied to them (Simmons et al., 1997), therefore drastic changes in environment conditions such as less dietary fat, and more physical activity, are likely to decrease the epidemic of obesity (Ravussin, 2000b). An unfavourable external environment which still promotes the use of a modern diet high in fat and energy, and low in fibre and associated with physical inactivity will however undermine sustainability in the individual. The consumption not only of reduced fat products, but also the reduction of the total amount of fat in food

supplied, such as dairy products and meat with a reduced fat content (Simmons et al., 1997), in order to reach the recommended fat intake of less than thirty percent per day of the total energy intake, should be promoted. Furthermore, a reduction in the consumption of energy dense diets low in fibre (O'Dea, 1991), should form part of this message.

Alteration in food supply through a local monopoly store in an Aboriginal community showed to be effective in reducing obesity. This intervention was aimed at increasing consumption of fruit and vegetables, and reducing the consumption of sugar and fat from meat (Lee et al., 1994). The focus should thus now fall on changes in the food supply in the local area and a community development approach to altering attitudes towards food choices. Without a supportive environment, treatment programmes are likely to be ineffective (Egger & Swinburn, 1997). In order to achieve these goals, support not only from local food retailers, but also from industry, will be necessary, as many foods low in total fat are currently marketed, but cost and local availability in the African townships are serious current constraints.

The dual role of diet and exercise as part of a healthy lifestyle should however be emphasised. Physical inactivity is now recognised as major risk factor for chronic diseases of lifestyle, making physical activity an ideal target for a public health intervention in this population group. Increased levels of physical activity, seem to be particularly useful in the treatment of obesity, because of its direct effects on muscle insulin sensitivity, while further lowering serum triglyceride levels, and assisting in maintaining a healthy body weight (Lambert et al., 2001). Leasure time activities should therefore be encouraged, and sedentary activities discouraged (Kalk, 2001), not only in adults, but also in young girls of school-going age. People must however be equipped

with knowledge, and believe in the health benefits of physical activity. Recommendations that individuals should accumulate thirty minutes of moderate to vigorous activity on most days should be promoted (Pate et al., 1995). Accessible facilities for leasure activities should be provided either by local authorities, or other institutions, in a safe environment, at affordable cost. A Community Health Intervention Programme (CHIPS) which consisted of a privately funded physical activity programme initiated by a non-profitable academic institution and a National Insurance Company in South Africa, and PATHWAYS, a church-based physical activity programme for weight loss in the USA, are good examples of intervention programmes (Lambert et al., 2001), which can be implimented and run at central venues in the local African community. Alternatively, a health promotion programme, with billboards providing health messages, an exercise group, a weight reduction group, and the training of community nutrition educators, such as the programme launched in Mamre near Cape Town (Levitt et al., 1999), could be introduced to support the message.

Medical management and nutritional management may be applied simultaneously, to control the risk for type 2 diabetes mellitus (James, 2001). The establishment of a station in the local community where community members can be screened for type 2 diabetes, and encouraged to adhere to a healthy lifestyle, should receive high priority in local health planning programmes.

These urban dwellers should be educated regarding the potential of diet and exercise to bring about changes in general health, and furthermore, they should be mobilised towards a healthier lifestyle in general.

The development of a community-based holistic, multidisciplinary programme aimed at

addressing lifestyle factors associated with disease, needs to be encouraged in the community of Mangaung.

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APPENDIX A

Central University of Technology, Free State

WOMENS NUTRITIONAL HEALTH SURVEY: WOMEN 25-44 YEARS OLD

SOCIO-DEMOGRAPHIC QUESTIONNAIRE

(All information in this questionnaire is confidential).

Name:_____

Respondent number: ☐☐☐ 1-3

Interviewer: ☐☐ 4-5

D D M M Y Y Y Y

Birth Date: ☐☐☐☐☐☐☐☐ 6-13

Interview Date: ☐☐☐☐☐☐☐☐ 14-21

Age (years) if Birth Date unknown:_____ ☐☐ 22-23

Address: _____

Tel No (H):_____ **(W):**_____

How many years have you been living in an urban area (like Mangaung)? ☐☐ 24-25

Encircle the appropriate answer:

Language: ☐ 26

1. Sotho
2. Tswana
3. English
4. Afrikaans
5. Other,

specify_____

Number of children: (born):_____ ☐☐ 27-28

Number of children: (alive):_____ ☐☐ 29-30

Do you smoke at all? ☐ 31

1. Yes
2. No

If yes, how many cigarettes per day? ☐☐ 32-33

Household composition:

How many persons live in the house permanently (5-7 days per week)?_____ ☐☐ 34-35

Number of children (< 18 yrs):_____ ☐☐ 36-37

Number of adults (≥ 18 yrs): _____ ☐☐ 38-39

Marital status of respondent: ☐ 40

1. Unmarried
2. Married
3. Divorced
4. Separated
5. Widowed
6. Living Together
7. Traditional Marriage
8. Other, specify_____

What is your highest level of education? ☐ 41

1. None
2. Primary School
3. Std 6-8
4. Std 9-10
5. Tertiary Education
6. Don't Know

Employment status of respondent ☐ 42

1. Housewife by choice
2. Unemployed
3. Self Employed
4. Full time wage earner (receive a salary)
5. Other, specify (part-time, peace job etc.)_____
6. Don't Know

Husband/ partner's employment status ☐ 43

1. Retired by choice
2. Unemployed
3. Self Employed
4. Full time wage earner (receive a salary)
5. Other, specify (part-time, peace job etc.)_____
6. Not Applicable e.g. dead

Who is the head of this household? ☐ 44

1. Self
2. Husband
3. Child/ren
4. Parent
5. Grandparent
6. Friend
7. Other, specify _____

Type of dwelling:

1. Brick, Concrete
2. Traditional mud
3. Tin
4. Plank, wood
5. Other, specify_____

Number of rooms in house (excluding bathroom, toilet and kitchen, if separate) ☐☐ 46-47

Where do you get drinking water most of the time? ☐ 48

1. Own tap
2. Communal tap
3. River, dam
4. Borehole, well
5. Other, specify _____

What type of toilet does this household have? ☐ 49

1. Flush
2. Pit
3. Bucket, pot
4. VIP
5. Other, specify _____

What fuel is used for cooking most of the time? ☐ 50

1. Electric
2. Gas
3. Paraffin
4. Wood, Coal
5. Sun
6. Open fire

Do you use a cast iron pot for cooking? ☐ 51

1. Never
2. ≤ Once a week
3. > Once a week
4. Every day

Does the home have a **working**:

Refrigerator and/or freezer ☐ 52

1. Yes
2. No

Stove (Gas, Coal or electric) or Hot Plate ☐ 53

1. Yes
2. No

Primus or Paraffin Stove ☐ 54

1. Yes
2. No

1. Yes
2. No

Radio and/or Television ☐ 56

1. Yes
2. No

How many people contribute to the total income? _____ ☐☐ 57-58

Household income per month (including wages, rent, sales of vegs, etc. State grants). ☐ 59

1. None
2. R100-R500
3. R501- R1000
4. R1001-R3000
5. R3001-R5000
6. Over R5000
7. Don't know

Is this more or less the income that you had over the past six months? ☐ 60

1. Yes
2. No

If no, is it more or less? ☐ 61

1. More
2. Less

How much money is spent on food weekly? ☐☐ 62-63

1. R0-R50
2. R51-R100
3. R101-R150
4. R151-R200
5. R201-R250
6. R251-R300
7. R301-R350
8. R351-R400
9. Over R 400

Central University of Technology, Free State

Nutritional Health of Women (20-44yrs) in Mangaung, 2000
Anthropometry

Name: _____

Respondent number: ☐☐☐ 1-3

Measurer (interviewer): _____ ☐☐ 4-5

Weight (kg): _____ ☐☐☐.☐ 6-10

Height (m): _____ ☐.☐☐ 11-14

Circumferences (cm):

Upper-arm: _____ ☐☐.☐ 15-18
Waist: _____ ☐☐.☐ 19-23
Hip: _____ ☐☐.☐ 24-28

Bio-impedance:

Age (yrs): _____ ☐☐ 29-30
Elbow width (cm): _____ ☐.☐ 31-33
Bodystat count: _____ ☐☐☐ 34-36

Frame size ☐ 37
1. Small
2. Medium
3. Large

% Fat: _____ ☐☐.☐ 38-41
% Lean mass: _____ ☐☐.☐ 42-45

Name:_____ | | | | 1-3
Respondent number:

Interviewer:_____ | | | 4-5

QUANTITATIVE FOOD FREQUENCY QUESTIONNAIRE

Greeting

Thank you for giving up your time to participate in this survey. We would like to find out what women 25 to 44 years of age and living in the Free State, usually eat and drink. This information is important to know as it will tell us whether you eat the right foods, and if you are healthy.

Please think carefully about the food and drinks you have consumed during the past 6 months. I will now go through a list of foods and drinks with you and I would like you to tell me:

- if you eat these particular foods,
- how the food is prepared,
- how much of the food you eat at a time, and
- how many times a day you eat it and if you do not eat it every day, how many times a week or a month it is eaten?

To help you to describe the amount of a food, I will show you pictures or models of different amounts of the food. Please say which picture or model is the closest to the amount eaten, or if it is smaller, between sizes or bigger than the pictures or models. Amounts can also be reported as cups (c), tablespoons (T) or teaspoons (t).

- **THERE ARE NO RIGHT OR WRONG ANSWERS.**
- **EVERYTHING YOU TELL ME IS CONFIDENTIAL.**
- **IS THERE ANYTHING YOU WANT TO ASK NOW?**
- **ARE YOU WILLING TO GO ON WITH THE QUESTIONS?**
- **ENCIRCLE APPROPRIATE ANSWER**

Do you follow any special diet? **YES (1)** **NO (2)** | 6

If yes, please specify (encircle appropriate answer) | 7

1. Diabetic diet
2. Slimming diet
3. Allergies
4. Other

(Specify)_____

- **Do you use salt in your food?** (1) NO (2) DON'T KNOW (3)
- **Are other, flavoured salts e.g. Aron your food?** (1) NO (2) DON'T KNOW (3) | 9

Please specify_____

- **Do you use beef/ chicken stock in your food?** YES (1) NO (2) DON'T KNOW (3) | 10
- **Do you use any dietary supplements?** YES (1) NO (2) DON'T KNOW (3) | 11

- If yes, please specify the type (name), how often, and how much:

Vitamins:_____ | 12-14

Minerals:_____ | 15-17

Protein:_____ | 18-20

Energy:_____ | 21-23

Other:_____ | 24-26

EATING PATTERNS: (FREQUENCY OF EATING)

PLEASE INDICATE WHICH OF THE FOLLOWING BEST DESCRIBES THE EATING PATTERN YOU USUALLY FOLLOW (MARK ONLY ONE):

- 1.More than three meals with eating between meals | 27
- 2.Three meals with eating between meals
- 3.Three meals with no eating between meals
- 4.Two meals with eating between meals
- 5.Two meals with no eating between meals
- 6.One meal with eating between meals
- 7.One meal with no eating between meals
- 8.Nibble the whole day, no specific meals
- 9.Others (Please specify): _____

DO YOU EAT BREAKFAST: | 28

- 1.Regularly (≥4 times a week)
- 2.Sometimes (1 – 3 times a week)
- 3.Never

HOW OFTEN DO YOU EAT AT THE FOLLOWING PLACES AWAY FROM HOME?

Family	1.Never	2.> once/week	3.Weekly	4.Monthly	5.> once a month	29
Friends	1.Never	2.> once/week	3.Weekly	4.Monthly	5.> once a month	30

					month	
Restaurant, Fast food	1.Never	2.> (	ekly	4.Monthly	5.> once a month	32
Other, specify _____	1.Never	2.> once/week	3.Weekly	4.Monthly	5.> once a month	33

Do you drink coffee with your meals? 34

- 1. Yes
- 2. No

If yes, at which meals

Breakfast	1. Yes	2. No	35
Lunch	1. Yes	2. No	36
Supper	1. Yes	2. No	37
Snacks	1. Yes	2. No	38

Do you drink tea (except Rooibos) with your meals? 39

- 1. Yes
- 2. No

If yes, at which meals

Breakfast	1. Yes	2. No	40
Lunch	1. Yes	2. No	41
Supper	1. Yes	2. No	42
Snacks	1. Yes	2. No	43

With how many meals per day do you eat meat, fish or poultry? 44

- 1. One meal
- 2. Two meals
- 3. All meals
- 4. None

Do you eat fresh fruit and/or vegetables with the following meals?

Breakfast	1. Yes	2. No	45
Lunch	1. Yes	2. No	46
Supper	1. Yes	2. No	47
Snacks	1. Yes	2. No	48

FOOD	CALCULATIO	CODE	AMOUNT PER DAY (g)
			(1-8)
			(9-16)
			(17-24)
			(25-32)
			(33-40)
			(41-48)
			(49-56)
			(57-64)
			(65-72)
			(73-80)
			(1-8)
			(9-16)
			(17-24)
			(25-32)
			(33-40)
			(41-48)
			(49-56)
			(57-64)
			(65-72)
			(73-80)
			(1-8)
			(9-16)
			(17-24)
			(25-32)
			(33-40)
			(41-48)
			(49-56)
			(57-64)
			(65-72)
			(73-80)
			(1-8)
			(9-16)
			(17-24)
			(25-32)
			(33-40)
			(41-48)
			(49-56)
			(57-64)
			(65-72)
			(73-80)
			(1-8)
			(9-16)
			(17-24)
			(25-32)
			(33-40)
			(41-48)
			(49-56)
			(57-64)
			(65-72)
			(73-80)

FOOD	DESCRIPTION	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom/ Never	
Maize-meal porridge	Stiff (pap)						**3400**
Maize-meal porridge	Soft (slappap)						**3399**
Maize-meal porridge	Crumbly (phutu)						**3401**
Sour porridge	Specify ratio Mabella/Maize						**3399**
Mabella porridge	Stiff, coarse, fine						**3437**
Mabella porridge	Soft, coarse, fine						**3437**
Oats porridge	Brand name:						**3239**
Breakfast cereals	Puffed Wheat, plain						**3325**
	Corn Flakes, plain						**3243**
	Weet Bix						**3244**
	Puffed Rice, sweet						**3372**
	Specify types usually eaten _____ _____ Brand names of cereals available at home now:_____						
Milk on porridge or cereal: Circle type usually used	None						
	Whole/fresh						**2718**
	Sour						**2787**
	2% fat						**2772**
	Fat free/skimmed						**2775**
	Milk blend						**2771**
	Soy milk						**2737**
	Condensed (whole,sweet)						**2714**
	Condensed (skim, sweet)						**2744**
	Evaporated whole						**2715**
	Evaporated low fat						**2827**
	Non-dairy creamer						**2751**
Is sugar added to porridge or cereal? (Tick box)	None ☐ White ☐ Brown ☐ Syrup ☐ Honey ☐ Sweetener: type_____						**3989** **4005** **3988** **3984**
Is fat added to porridge or cereal? (Tick box)	None ☐ Animal fat (butter) ☐ Hard margarine ☐ Soft margarine ☐ Oil ☐ Peanut Butter ☐						**3479** **3484** **3496** **3507** **3485**
Samp/Maize rice **Samp and beans** **Samp and peanuts**	Bought Self ground Specify ratio (1:1) Specify ratio						**3250** **3725** **3402**
Rice: specify brands names:	White Brown Sorghum rice						**3247** **3315** **3437**

X

Pastas	Macaroni Spaghetti Spaghetti in tomato sauce Other:				**3262** **3262** **3258**	

HOW MANY TIMES A WEEK DO YOU EAT PORRIDGE OR BREAKFAST CEREAL AT ANY TIME OF THE DAY (NOT ONLY BREAKFAST)?_____

FOOD	DESCRIPTION	AMOUNT USUALLY EATEN	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom/ Never		
Bread/Bread rolls	White						**3210**	
Bread slices: thin	Brown						**3211**	
Medium, thick	Whole wheat						**3212**	
Other breads	Specify types e.g. Raisin Maize meal Sweetcorn Rye Other						 **3214** **3278** **3379** **3213**	
Pizza (specify toppings) **Hot Dogs(specify sausage)** **Hamburgers (specify meat)**	Cheese, tomato & onion _____ _____ _____ _____ _____						**3353**	
Are any the following spreads used on bread? **Fat spreads (Tick box)**	Butter ☐ Butro ☐ Animal fat (beef tallow) ☐ Lard ☐ Hard margarine (brick) ☐ Soft margarine (light) ☐ Cooking Fat ☐						**3479** **3523** **3494** **3495** **3484** **3496** **3516**	
Peanut butter							**3485**	
Sweet spreads	Jam Syrup Honey						**3985** **3988** **3984**	
Marmite/ OXO/ Bovril							**4030** **4029** **4029**	
Fish paste **Meat paste**							**3109** **2917**	
Cheese	Specify types: Cottage low-fat cheese Cream cheese Gouda Cheddar Other:_____ _____						 **2760** **2725** **2723** **2722**	
Cheese spreads	Low fat Full fat Specify types						**4310** **2730**	
Atchar							**3117**	
Other spreads: (Specify tipes)	_____							

Dumpling							3210	
Vetkoek							3257	
Provita **Crackers (refined)** **Crackers (whole wheat)**							3235 3331 3391	
Rusks	Bran Buttermilk White Boerebeskuit, white						3330 3329 3364 3364	
Home-made:	All-bran Raisins Buttermilk, white Buttermilk, whole wheat Other						3380 3380 3215 3255	
Scones							3237	
Muffins	Plain Bran						3408 3407	

HOW MANY TIMES A DAY DO YOU EAT BREAD? _____

	DESCRIPTION	AMOUNT USUALLY EATEN	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom/ Never		
Chicken	Boiled: with skin without skin						2926 2963	
Do you eat the chicken with the skin? **Yes** ☐ **No** ☐	Fried: in batter/crumbs Fried, but not coated						3018 2925	
	Roasted/grilled with skin without skin						2925 2950	
Chicken bones stew							A003	
Chicken heads, raw							2999	
Chicken stew, with veg. & skin							3005	
Chicken feet, raw							2997	
Chicken offal	Giblets						2998	
Chicken pie	Commercial Home-made						2954 2954	
Red meat: Beef	Fried/grilled: with fat without fat						2908 2959	
	Stewed/boiled: with fat without fat						3006 2909	
	Mince with tomato and onion						2987	
Red meat: Mutton	Fried/grilled: with fat without fat						2927 2934	
	Stewed/boiled: with fat without fat						3040 2916	
Red meat: Pork	Fried/grilled: with fat without fat						2930 2977	
	Stewed/boiled: with fat without fat						3046 3045	

Dumpling							3210	
Vetkoek							3257	
Provita							3235	
Crackers (refined)							3331	
Crackers (whole wheat)							3391	
Rusks	Bran						3330	
	Buttermilk						3329	
	White						3364	
	Boerebeskuit, white						3364	
Home-made:	All-bran						3380	
	Raisins						3380	
	Buttermilk, white						3215	
	Buttermilk, whole wheat						3255	
	Other							
Scones							3237	
Muffins	Plain						3408	
	Bran						3407	

HOW MANY TIMES A DAY DO YOU EAT BREAD? _____

	DESCRIPTION	AMOUNT USUALLY EATEN	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom/ Never		
Chicken	Boiled: with skin						2926	
	without skin						2963	
Do you eat the chicken with the skin?	Fried: in batter/crumbs						3018	
	Fried, but not coated						2925	
Yes ☐ **No** ☐	Roasted/grilled						2925	
	with skin							
	without skin						2950	
Chicken bones stew							A003	
Chicken heads, raw							2999	
Chicken stew, with veg. & skin							3005	
Chicken feet, raw							2997	
Chicken offal	Giblets						2998	
Chicken pie	Commercial						2954	
	Home-made						2954	
Red meat: Beef	Fried/grilled: with fat						2908	
	without fat						2959	
	Stewed/boiled: with fat						3006	
	without fat						2909	
	Mince with tomato and onion						2987	
Red meat: Mutton	Fried/grilled: with fat						2927	
	without fat						2934	
	Stewed/boiled: with fat						3040	
	without fat						2916	
Red meat: Pork	Fried/grilled: with fat						2930	
	without fat						2977	
	Stewed/boiled: with fat						3046	
	without fat						3045	

Red meat: Goat	Fried/grilled: with fat / without fat						**4281**	
	Stewed/boiled: plain / with veg						**4281 4282**	
Offal: Specify type:	Intestines: boiled, nothing added						**3003**	
	"Vetderm" fried						**3003**	
	Stewed with vegetables							
	Liver						**2955**	
	Kidney						**2956**	
	Tripe "pens" trotters, head						**3003**	
	Pluck (lungs, heart, gullet)						**3019**	
Specify vegetables used in meat stews (only if not mentioned elsewhere)								
Wors / sausage	Fried						**2931**	
Bacon							**2906**	
Cold meats	Polony						**2919**	
	Ham						**2967**	
	Vienna's canned						**2936**	
	Russian						**2948**	
	Frankfutter						**2937**	
	Other (specify)							
Canned meat	Bully beef						**2940**	
	Other (specify)							
Meat pie	Bought						**2939**	

FOOD	DESCRIPTION	AMOUNT USUALLY EATEN	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom/ Never		
Legumes: specify dried beans/peas/ Lentils	Stews & curries (specify) Soups Salad						**3157** **3174**	
Baked beans							**3176**	
Soya products e.g. Toppers/ Imana	Brands at home now Don't know_____ **Show examples**						**3196**	
Fried fish (fresh or frozen fried in sun oil)	With batter/crumbs Without batter/crumbs						**3072** **3060**	
Fresh water fish **Specify type**	**Specify cooking method** Medium fat, batter, fried						**3094**	

Canned fish:								
Pilchards	In brine						**3055**	
	In tomato sauce						**3102**	
	Mashed with fried onion						**A005**	
Sardines	In oil In tomato sauce						**3087** **3087**	
Tuna	In oil In brine						**3093** **3054**	
Mackerel							**3113**	
Salmon							**3101**	
Pickled fish/curried							**3076**	
Do you remove fish bones before eating canned fish	YES ☐ NO ☐							
Fish cakes Specify canned or other	Fried: oil/butter/margarine, commercial						**3080**	
Salted dried fish							**3077**	
Eggs	Boiled/poached Scrambled in: oil butter margarine Fried in: oil butter margarine bacon fat Curried						**2867** **2889** **2886** **2887** **2869** **2868** **2877** **2870** **2902**	

HOW MANY TIMES A WEEK DO YOU EAT MEAT _____,

BEANS _____,

CHICKEN _____,

FISH _____ **AND**

EGGS _____?

FOOD	DESCRIPTION	AMOUNT USUALLY EATEN	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom / Never		
Cabbage	Boiled, nothing added						**3756**	
	Boiled with potato and onion and fat						**3813**	
	Fried, in margarine (nothing added)						**3810**	
	Fried, in oil (nothing added)						**3912**	
	Boiled, then fried with potato, onion						**A006**	
	Other:							

morogo/ imfino/other green leafy vegetables: List names	Boiled fat added (margarine)						**3898**	
	Boiled with onion/tomato and fat						**A011**	
	-onion &potato (margarine)						**3901**	
	- onion, tomato & potato							
	- with peanuts							
	Other:							
Tomato and onion 'gravy'/relish /chow	Home made-with fat without fat						**3910** **3925**	
	Canned						**4129**	
Pumpkin Specify type:	Cooked in fat & sugar						**A010**	
	Boiled, little sugar and fat						**A010**	
	Boiled						**4164**	
_____	Other:							
Carrots	Boiled, sugar & fat						**3819**	
	Boiled, nothing added						**3757**	
	Boiled, potato, onion, no fat						**3934**	
	Boiled, potato, onion, margarine						**3822**	
	Boiled, with sugar						**3818**	
	With potato/onion						**3934**	
	Raw, salad (orange juice)						**3711**	
	Chakalaka							
	Other:							
Mealies/ Sweet corn	On cob						**3725**	
	Off cob -creamed sweet corn Off cob whole kernel						**3726** **3942**	
Beetroot	Cooked Salad (bought or home-made)						**3698** **3699**	

FOOD	**DESCRIPTION**	**AMOUNT USUALLY EATEN**	**TIMES EATEN**				**CODE**	**AMOUNT/ DAY**
			Per day	**Per week**	**Per month**	**Seldom/ Never**		
Potatoes	Boiled with skin						**4155**	
	without skin						**3737**	
	Baked in skin(flesh and skin) - in skin (flesh only)						**3736** **3970**	
	Mashed - skim milk, margarine						**3875**	
	Mashed - whole milk, margarine						**3876**	
	Roasted in beef fat						**3878**	
	French fries/potato chips (oil)						**3740**	
	Salad (mayonnaise and egg)						**3928**	
	Other:							

potatoes	- without skin						3903	
	Baked - with skin						3748	
	- without skin						3903	
	Mashed						3903	
	Other:							
Peas	Green, frozen						4146	
	Green, frozen with sugar						3720	
	With sugar and butter						3859	
	Tinned peas						4149	
Green peppers	Raw						3733	
	Cooked (stew with oil)						3865	
Brinjal/egg plant	Cooked						3700	
	Fried in oil						3802	
	Stew (oil, onions, tomato)						3798	
Mushrooms	Raw						3842	
	Sautéed in brick margarine						3839	
	Sautéed in oil						3841	
Onions	Sauteed in sun oil						3730	
	Sauteed in margarine						3844	
Salad vegetables	Raw tomato						3750	
	Lettuce						3723	
	Cucumber						3718	
	Avocado's						3656	
Green Beans	Boiled, nothing added						3696	
	Cooked, potato, onion, margarine						3792	
	Cooked, potato, onion, no fat						3933	
Cauliflower							3716	
Other vegetables; specify	_____							
If you fry veg or add fat specify type of fat usually used	Butter ☐						3479	
	Butro ☐						3523	
	Animal fat (beef tallow) ☐						3494	
	Lard ☐						3495	
	Hard margarine (brick) ☐						3484	
	Soft margarine (tub) ☐						3496	
	Soft margarine (light) ☐						3524	
	Sunflower oil ☐						3507	

HOW MANY TIMES A WEEK DO YOU EAT VEGETABLES? _____

FOOD	DESCRIPTION	AM USU EA	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom/ Never		
Mayonnaise/ salad dressing	Mayonnaise: bought home-made Cooked salad dressing Salad dressing low-oil Salad dressing French Oil: Olive Sunflower Canola						**3488** **3506** **3503** **3505** **3487** **3509** **3507** **4280**	
Apples	Fresh Canned, unsweetened						**3532** **4216**	
Pears	Fresh Canned, in syrup						**3582** **3583**	
Bananas							**3540**	
Oranges **Naartjie**							**3560** **3558**	
Grapes							**3550**	
Peaches	Fresh Canned, in syrup						**3565** **3567**	
Apricots	Fresh Canned, in syrup						**3534** **3535**	
Mangoes	Fresh						**3556**	
Pawpaw	Raw						**3563**	
Pineapple	Raw Canned (syrup)						**3581** **3648**	
Guavas	Fresh Canned (syrup)						**3551** **3553**	
Watermelon							**3576**	
Spanspek	Orange flesh Green flesh						**3541** **3575**	
Wild fruit/berries (Specify types)	_____ _____ _____ _____ _____							
Dried fruit (also as snacks)	Raisins Prunes (raw) Prunes (cooked with sugar) Peaches (raw) Peach (cooked with sugar) Apples (raw) Dried fruit sweets Other _____ _____ _____						**3552** **3596** **3564** **3568** **3569** **3600** **3995**	
Other fruit	_____ _____ _____ _____ _____ _____ _____ _____	_____ _____ _____ _____ _____ _____ _____ _____	_____ _____ _____ _____ _____ _____ _____ _____	_____ _____ _____ _____ _____ _____ _____ _____	_____ _____ _____ _____ _____ _____ _____ _____	_____ _____ _____ _____ _____ _____ _____ _____		_____ _____ _____ _____ _____ _____ _____ _____

HOW MANY TIMES A WEEK DO YOU EAT FRUITS? _____

BEVERAGES	DESCRIPTION	AMOUNT USUALLY TAKEN	TIMES TAKEN				CODE	
			Per day	Per week	Per month	Seldom/ Never		
Water							**4042**	
Tea	Ceylon Rooibos						**4038** **4054**	
Coffee							**4037**	
Sugar per cup of tea or coffee	White Brown						**3989** **4005**	
Milk per cup of tea or coffee	Fresh/long life whole						**2718**	
What type of milk do you put in tea and/or coffee?	Fresh/long life 2% Goat						**2772** **2738**	
	Fresh/long life/fat free (skimmed)						**2775**	
	Whole milk powder, reconstituted Specify brand: _____						**2831**	
	Skimmed milk powder, reconstituted Specify brand: _____						**2719**	
	Milk blend, reconstituted Specify brand: _____						**2771**	
	Whitener/non-dairy creamer Specify brand: _____						**2751**	
	Condensed milk (whole)						**2714**	
	Condensed milk (skim)						**2744**	
	Evaporated milk (whole)						**2715**	
	Evaporated milk (low-fat)						**2827**	
	None							
Milk as such: What type of milk do you drink as such?	Fresh/long life/whole Fresh/long life/2% Fresh/longlife/fat free (skimmed) Goat						**2718** **2772** **2775** **2738**	
	Sour / Maas						**2787**	
	Buttermilk						**2713**	

BEVERAGES	DESCRIPTION	AM US T	TIMES TAKEN				CODE	AMOUN DAY
			Per day	Per week	Per month	Seldom/ Never		
Milk drinks Specify brands, Including milk supplements and type of milk used	Nestle Nesquik_____ Milo_____ Flavoured milk_____ Other						**4287** **2735** **2774**	
Yoghurt	Drinking yoghurt Thick yoghurt, plain, fruit						**2756** **2732**	
Squash	SixO Oros Lecol with sugar -artificial sweetener Kool Aid Other_____ _____						**3990** **3982** **3982** **3990** **3982**	
Fruit juice	Fresh/Liquifruit/Ceres/						**2866**	
	"Tropica"/ mixtures with milk						**2791**	
Fruit syrups	Average Guava syrup						**2865** **2864**	
Fizzy drinks Coke, Fanta	Sweetened Diet						**3981** **3990**	
Mageu/ Motogo							**4056**	
Alcoholic beverages such as Sorghum beer	Sorghum beer Specify:						**4039**	
Other , specify:	Beer average Wine Cider _____ _____ _____ _____ _____ _____						**4031** **4033** **4057**	

PLEASE INDICATE WHAT TYPES AND AMOUNTS OF SNACKS, PUDDINGS AND SWEETS YOU EAT:

FOODS	DESCRIPTION	AMOUNT USUALLY EATEN	TIMES EATEN				CODE	AMOUN DAY
			Per day	Per week	Per month	Seldom/ Never		
Potato crisps/chips							**3417**	
Peanuts	Roasted, unsalted Roasted, salted						**3452** **3458**	

curls: Niknaks etc.	Savoury						3418	
Popcorn	Plain (no salt and butter) Plain (salt and butter added) Sugar coated						3332 3359	
Raisins (seeds)							4231	
Chocolates	Milk Kit Kat Peppermint crisp Specify types and names _____						3987 4024 3997	
Candies	Sugus, gums, hard sweets (specify) Peppermint						3986 4004	
Sweets	Toffees Hard boiled Fudge, caramels (specify)						3991 3986 3991	
Biscuits/ cookies	Specify type Home made plain Shortbread, butter Commercial, plain Commercial with filling						 3233 3296 3216 3217	
Cakes & tarts	Chocolate, plain						3419	
Pancakes/ crumpets							3344	
Koeksisters							3231	
Savouries	Sausage rolls Samoosas - vegetable Samoosa - mutton Biscuits e.g. bacon kips Other:						2939 3414 3355 3331	
Pudding: jelly							3983	
Baked pudding	Plain batter						3429	
Instant pudding	Skim milk Whole milk						3314 3266	
Ice cream	Commercial regular Commercial rich Soft serve Sorbet Ice lollies Chocolate coated individual ice creams (e.g. Magnum)						3483 3519 3518 3491 3982	
Custard	Home made, whole milk Ultramel						2716 2716	
Cream	Fresh						3520/ 3480	
Other puddings (Specify):	_____							

HOW MANY TIMES A WEEK DO YOU EAT SNACK FOODS? _____

XX

FOODS	DESCRIPTION	AMOUNT USUALLY EATEN	TIMES EATEN				CODE	AMOUNT PER DAY
			Per day	Per week	Per month	Seldom/ Never		
Tomato Sauce Worcester sauce							3139 4309	
Chutney	Fruit						3168	
	Tomato						3114	
Pickles							3866	
Packet soups							3158	
Beef/ chickenstock							4029	
Others:								

WILD BIRDS, ANIMALS, INSECTS OR FRUITS AND BERRIES (hunted or collected in rural areas or on farms: (specif

- **PLEASE MENTION ANY OTHER FOODS YOU EAT MORE THAN ONCE EVERY TWO WEEKS WHICH WE HAVE NOT TALKED ABOUT AND OR FOODS EATEN IN OTHER HOMES OR PLACES DURING THE PAST WEEK**

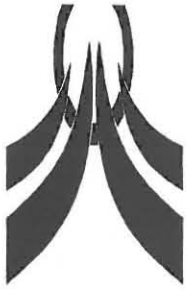
FOOD	DESCRIPTION	AMOUNT USUALLY EATEN	TIMES EATEN				CODE	AMOUNT PER DAY
			Per day	Per week	Per month	Seldom/ Never		

- **ARE THERE ANY FOODS THAT YOU EAT WHICH WE HAVEN'T TALKED ABOUT? PLEASE LIST THEM.**

FOODS	DESCRIPTION	AMOUNT USUALLY EATEN	TIMES EATEN				CODE	AMOUNT PER DAY
			Per day	Per week	Per month	Seldom/ Never		

THANK YOU FOR YOUR CO-OPERATION AND PATIENCE.
GOOD BYE!

ADAPTED FROM THE QUESTIONNAIRES OF THE THUSA STUDY (WITH ACKNOWLEDGEMENT TO THE RESEARCH GROUP OF PUCHO) AND THE NATIONAL FOOD CONSUMPTION SURVEY



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APPENDIX D

THE COMMUNITY OF NAMIBIA

This letter serves to inform the community of a research project titled " The nutritional health of women (25-44 years) in Mangaung" that will be undertaken by the Technikon Free State, University of the Orange Free State and the National Research Foundation during 2000. The project is aimed at investigating the change from the traditional healthy diet to a more Western unhealthy diet. The influence of this change of diet on health will be determined.

A random selection of 500 households in Bochabela, Phahameng, Joe Slovo and Namibia will be made to be included in the study. The women living in these households will be contacted by the community health workers and they will be asked whether they are interested in participating in the study. If they agree they will be fetched from Mangaung and taken to the Technikon for one day. No one will be forced to participate in the study.

On the day that they participate in the study a free medical examination will be done, blood will be drawn (including a HIV test), and they will be asked a number of questions about general background, what they eat, how active they are, and attitude towards health. None of the questions are difficult and anyone will be able to answer these questions.

The information will help to determine nutritional problems in women and to develop solutions for these problems. The project will benefit the community since we will be able to determine what interventions are required to improve the health of women in South Africa. The project will not cause any harm to the participants in any way. By participating in the research survey you will help other women in the country. The individual information will be kept strictly confidential. Women that participate will be paid an amount of R40.00 for their time. Please feel free to contact the community health workers at any time if you have any questions about the project.

DR CORINNA WALSH
PROJECT COORDINATOR

NUTRITIONAL HEALTH OF WOMEN (25-44 YEARS) IN MANGAUNG, 2000

Ethics committee reference number: 02/00

Declaration by or on behalf of the participant:

Respondent number ☐☐☐

I, the undersigned, ...

[ID.....]

.....(address)

A confirm that:

1. I have been asked to participate in the above-mentioned research survey carried out by the Technikon Free State and University of the Orange Free State

2. It has been explained to me that:

2.1 The purpose of the research survey is to collect information on usual food intake, activity level, attitude towards health, risk for developing illnesses related to eating habits and lifestyle of women in the ages 25 to 45 years in Mangaung. The information collected will be used to determine nutritional problems and to develop solutions for these problems.

2.2 In order to collect this information I have been told that I will be asked a number of questions regarding:

- general background information;
- the types and amounts of foods I eat and how often I eat these foods;
- how active I am every day;
- my attitude towards leanness and fatness;

2.3 I also understand that a medical doctor will perform a free medical examination and that blood samples will be drawn by a registered nurse. One of these blood samples will include a test for HIV-AIDS. I also agree to be weighed and measured. I will not eat or drink anything after 10:00 of the evening preceding the research day. I will bring a list of the medication that I usually use with me on the research day.

2.4 I have been told that this information will be collected from over 500 women in Mangaung and I will only be asked these questions once. The measurements and blood samples will also be taken once only.

2.5 I have been told that it will not take [redacted] to collect the information.

3 I have been told that the measurements will not cause any harm to me in any way.

4 It was also explained to me that by participating in the research survey I will help other women in the country.

5 It was also explained to me that the information will be kept confidential but that it will be used anonymously for making known the findings to other scientists.

6. I understand that I will have no direct access to the results of the survey but I can contact the researcher who will inform me of the findings.

7. It was also clearly explained to me that I can refuse to participate in this research survey. If I refuse, it will not be not be held against me in any way.

8. The information in this consent form was explained to me by ……(name of interviewer) in ……(language) and I confirm that I have a good command in this language and understood the explanations. I was also given the opportunity to ask questions on things I did not understand clearly.

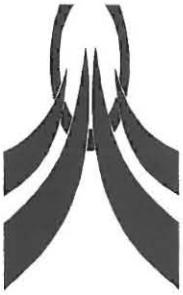
9. No pressure was applied on me to take part in this research survey.

10. Finally, after completion of my participation in this research survey I will receive a payment of R40. I will be responsible for my own transport home.

B I hereby agree voluntarily to take part in this research survey.

Signed/confirmed at ..... on 2000

.....	.....
Signature or hand mark of Participant	Signature or hand mark of Witness



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APPENDIX F

THE EMPLOYER

This letter serves to certify that _____ has been randomly selected to participate in a research project, undertaken by the Technikon Free State, University of the Orange Free State and the National Research Foundation on the _____ (date).

The project will investigate the nutritional health of women (25-45 years) living in Mangaung. The purpose of the project is to collect information on usual food intake, activity level, attitude toward health, as well as risk for developing diseases related to eating habits and life-style. The information collected will be used to determine nutritional problems and to develop solutions to these problems. The participant will be required to be available for the full duration of the day.

Your kind consideration is appreciated.

Die werkgewer

Hiermee word bevestig dat _____ gekies is om deel te neem aan 'n navorsingsprojek wat onderneem word deur Technikon Vrystaat, die Universiteit van die Oranje Vrystaat en die Nasionale Navorsings Stigting op die _____ (datum).

Die projek ondersoek die voedinggesondheid van vroue (25-45 jaar) wat in Mangaung woonagtig is. Die doel van die projek is om inligting te versamel oor gewoontelike voedselinname, aktiwiteitsvlak, houding teenoor gesondheid, sowel as risiko om siektes te ontwikkel wat verband hou met eetgewoontes en lewenstyl. Die inligting sal gebruik word om voedingsprobleme te identifiseer en om oplossings vir daardie probleme te ontwikkel. Die deelnemer sal die hele dag beskikbaar moet wees.

U goedgunstige oorweging word waardeer.

DR CORINNA WALSH
PROJECT COORDINATOR/ PROJEK KOöRDINEERDER